UNIV. OF
TORONTO
LIBRARY

Digitized by the Internet Archive
in 2011 with funding from
University of Toronto

http://www.archive.org/details/lightlighting12illu

Techno

Light and Lighting

JAN. to DEC., 1919.

ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited · by
LEON GASTER

12/6 Yearly. THE JOURNAL OF SCIENTIFIC ILLUMINATION. 1/3 a Copy

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

University of Toronto Library

156929
2/11/20

VOL. XII.

JAN. 1919 TO DEC. 1919

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,
32, VICTORIA STREET, LONDON, S.W.1
(TEL. NO. VICTORIA 5215.)

TP
700
L54
v.12

AUTHORS' INDEX.

A

PAGE

- An Engineering Correspondent on—
  - Special Problems in the Lighting of Laboratories, etc. 13
  - Lighting a Boxing Arena 134
  - The Shipping, Engineering, and Machinery Exhibition 297
- Applebee, G. A., on Stage Lighting 129
- Archer, W., on Stage Lighting 124
- Arundel, N., on The Gas-filled Lamp 165

B

- Baker, C. A., on the Gas-filled Lamp 104
- Beilby, Sir Geo., on Tenth Anniversary Dinner (I.E.S.) 99
- Blain, H. C., on Tenth Anniversary Dinner (I.E.S.) 104
- Blok, A., on the Gas-filled Lamp 162
- Bond, H. I., on Railway Lighting 81
- Booth, N., on Stage Lighting 126
- Boyce, O. L., on Office Lighting 46
- Bussell, R. C., on Office Lighting 46

C

- Campbell, Swinton A. A., on Tenth Anniversary Dinner (I.E.S.) 100
- Carter, H. A., on Street-lighting Reconstruction Problems 236
- Cash, H. J., on The Gas-filled Lamp and Illuminating Engineering 163
- Clark, J. G., on Street-lighting Reconstruction Problems 234
- Clinton, W. C., on—
  - Street-lighting Reconstruction Problems 236
  - Recent Developments in Public and Private Lighting 281
- Cole, H. W., on The Gas-filled Lamp and Illuminating Engineering 164
- Cunnington, A., on—
  - Railway Lighting and its Maintenance 164
  - Office Lighting 45

D

- Darch, J., on—
  - Office Lighting 48
  - Stage Lighting 128
- Dennison, F. S., on Office Lighting 45
- Dimmack, A., on The Gas-filled Lamp and Illuminating Engineering 179

PAGE

- Dow, J. S., on—
  - Office Lighting 47
  - Stage Lighting 131
  - The Gas-filled Lamp and Illuminating Engineering 166

F

- Fagan, J. B., on The Art of Stage Lighting 118
- Fleming, A. P. M., on The Planning of a Works Organisation 9
- Freedman, P., on New Types of Pointolite Lamps 324
- Freeman, E., on The Gas-filled Lamp and Illuminating Engineering 165

G

- Garbett, G. P., on Office Lighting 46
- Gaster, L., on—
  - Editorials 1, 21, 53, 89, 113, 137, 175, 201, 239, 279, 307, 331
  - Railway Lighting 81
  - Tenth Anniversary Dinner (I.E.S.) 100
  - The Gas-filled Lamp and Illuminating Engineering 165
  - Scientific Lighting and Industrial Efficiency 188
  - Street-lighting Reconstruction Problems 225
  - Notes on Events during the Vacation 316
- Goodenough, F. W., on—
  - Railway Lighting 79
  - Tenth Anniversary Dinner (I.E.S.) 97
  - Street-lighting Reconstruction Problems 233
- Goody, H. E., on Lighting Vulgarities 300
- Goulden, T., on Tenth Anniversary Dinner (I.E.S.) 94
- Greenslade, C. E., on Street-lighting Reconstruction Problems 235
- Gregory, Sir Richard, on Science and Industry 183

H

- Haigh, J. H., on Railway Lighting 78
- Harrison, Haydn T., on—
  - Railway Lighting 76
  - The Gas-filled Lamp and Illuminating Engineering 161
  - Street-lighting Reconstruction Problems 236
  - A New Form of Illumination Photometer 328
- Howgrave, Graham R. P., on Stage-Lighting 127

J

PAGE

Jeffries, Z., on the Metallography of Tungsten 110
Jones, J. H., on Office Lighting 44

L

Lancaster, E. W., on The Gas-filled Lamp and Illuminating Engineering .. 165, 180
Lane Crawford, G., on Stage Lighting .. 127
Langlands, S. B., on The Gas-filled Lamp and Illuminating Engineering 163
Legge, Dr. T. M., on Tenth Anniversary Dinner (I.E.S.) 107
Lux, H., on Glare and Shadow Contrast .. 294

M

Martin, L. C., on The Sheringham Daylight 323
McDermott, N., on Stage Lighting .. 126
MacDonald, M., on Railway Lighting .. 84
McOmber, L. W., on Cinema Lighting .. 291
Moore, E. S. D., on Railway Lighting .. 82
Morison, G. E., on Stage Lighting .. 125

P

Parsons, J. Herbert, on Tenth Anniversary Dinner (I.E.S.) 99
Paterson, C. C., on Carbon Arcs for Searchlights 335
Peri, G., on Courses on Illuminating Engineering in Italy 16
Perkin, H., on Railway Lighting .. 79
Prangnell, N. W., on Railway Lighting 82
Priest, J. G., on Signalling with Ultra-Violet Rays 295
Pykett, F., on The Group and Duct System of High Pressure Lighting 108

R

Raffé, W. G., on Stage Lighting .. 127
Robarts, H. E., on Railway Lighting .. 81

S

Searle, Mrs. K., on Stage Lighting .. 126
Shufflebotham, F., on Mine Lighting and Safety 136
Steel-Maitland, Sir Arthur, on Overseas Trade and the Press 106

PAGE

Stephens, J. N., on Street Lighting .. 236
Stevens, A. H., on Railway Lighting .. 78
Stickney, G. H., on Industrial Lighting Codes (U.S.A.) 191
Swan, F. A., on an Apparatus for Recording Daylight 134
Swift McNeill, J. G., on Night Sittings in the House of Commons 112

T

Thompson, Dr. E., on Short Sight in School Children 296
Trotter, A. P., on—
  Office Lighting 47
  Tenth Anniversary Dinner (I.E.S.) .. 96
  Stage Lighting 129
  Diffused Reflexion and Transmission of Light 243
  Lambert and Photometry 313
  Artificial Daylight 341
Tuck, D. H., on Maintenance of Industrial Lighting 273

U

Utterback, C. L., on Transmission of Coloured Light through Fog 269

V

Vernon, H. M., on Industrial Accidents .. 195
Vogt, J., on Industrial Lighting Code in New York 191

W

Waldram, P. J., on Office Lighting .. 46
Walsh, J. W. T., on Stage Lighting .. 126
Ward Harrison, on—
  Street Lighting and Traffic Accidents 286
  Lighting of Underground Passages 292, 338
Webb, G. E., on The Principles of Scientific Illumination 195
Whiteside, J., on Industrial Accidents and Lighting 271
Whysall, P., on Railway Lighting .. 78
Wilkinson, G., on The Gas-filled Lamp and its effect on Illuminating Engineering 166
Willcox, F. W., on—
  Office Lighting 39
  The Gas-filled Lamp and its Effect on Illuminating Engineering .. 143, 168
Williams, C. R., on Railway Lighting .. 87
Wise, A., on Modern Practice in Office Lighting 39

SUBJECT INDEX.

A

PAGE

Accidents and "Safety First" Methods 18
Accidents caused by Street Vehicles 136, 286, 340
Accidents, Industrial 52
Aerial Navigation, Lighting in relation to 52
Agriculture, Lighting and 52
Architecture and Illumination 187
Arc Lamp Globes, Colouration of under the action of Light 187
Artificial Daylight, by A. P. Trotter .. 341

B

Beacon, an interesting form of 340
Benjamin Franklin as a Daylight Saving Advocate 196
Boxing Arena, the Lighting of a .. 134
British Science Guild, Dinner 8
British Scientific Products Exhibition, The 88, 183

C

Canadian Mission in London, The .. 112
Candles and Superstitions 296
Carbon Arcs for Searchlights, by C. C. Paterson, J. W. T. Walsh, A. K. Taylor, and W. Barnett 335
Careers for Ex-Service Men 278
Cinema Halls, Lighting the Interiors of 283, 290
CIRCLE OF SCIENTIFIC, TECHNICAL AND TRADE JOURNALISTS—
    Overseas Trade and the Press .. 106
    Meeting at British Scientific Products Exhibition 183
    Visit to Slough 353
City of London, Lighting of 340
Classroom Lighting in a Factory in Germany 12
Coloured Light, Transmission of through Fog, by C. L. Utterback .. 241, 269

D

Daylight, Apparatus for Recording .. 134
Daylight, Artificial 323, 341
Diffused Reflexion and Transmission of Light, by A. P. Trotter 243

E

Editorials, by L. Gaster 1, 21, 53, 89, 113, 137, 175, 201, 239, 279, 307, 331
Electric Incandescent Lamps, Inspection Tests of 274

PAGE

Electric Lighting, Progress in U.S.A. in 1918 194
Exhibitions, The Lighting of (Editorial) 281
Eye, Effect of Coloured Light on .. 270

F

Factory Lighting, Need for Legislation on (Editorial) 91
Factory Lighting, Natural and Artificial (Editorial) 334
Factory Lighting, Progress in Legislation in U.S.A. 191
Factories and Shipyards, Lighting of .. 271
Focus Type of Metal Filament Lamp, A 39
Fog, Transmission of Coloured Light through, by C. L. Utterback 269

G

Gas, A New Basis of Rating for (Editorial) 309
Gas and Electricity and Illuminating Engineering (Editorial) 56
Gas Burners, Free Maintenance of .. 285
Gas, Standards for on a Heat-Energy Basis (Editorial) 115
Gas-filled ("half-watt") Lamp and its Effect on Illuminating Engineering, by F. W. Willcox 143, 179
Gas-filled Lamp, Tests of the 182
Gas-filled Lamp, with Opal Glass Bulb, The 326
Gas Lighting, Use of on Festive Occasions 343

H

Heat Radiation, Uses of in War .. 295
Headlights for Motor Vehicles 52
High Pressure Gas Lighting, Group and Duct System of 108
House of Commons, Night Sittings in the 112

I

Illuminations in Celebration of Peace (Editorial) 139
Illuminating Engineering Abroad (Editorial) 23
Illuminating Engineering, Courses on in Italy 16
Illuminating Engineering, Calculations and Standardisation (Editorial) .. 127
Illuminating Engineering in Germany .. 294
Illuminating Engineering, Recent Developments in (Editorial) 307
Illuminating Engineering, A Year's Progress in U.S.A. 345

PAGE

Illuminating Engineering Society (U.S.A.)—
  1919 Convention of (Editorial) .. 310
  Papers for Session 1919–1920 .. 349

Illuminating Engineering Society
(Founded in London, 1909.)
  Accounts of Meetings 25, 57, 117, 141, 205, 311
  New Members 25, 57, 117, 141, 205, 311
  Modern Practice in Office Lighting, by A. Wise 27
  Some Notes on Railway Lighting and its Maintenance, by A. Cunnington 59
  Tenth Anniversary Dinner .. 91, 93
  The Art of Stage Lighting, by J. B. Fagan 119
  The Gas-filled (" half-watt ") Lamp and its Effect on Illuminating Engineering, by F. W. Willcox .. 141
  Annual Meeting 205
  Report of the Council for the Session November, 1918–June, 1919 .. 207
  The Work of the Illuminating Engineering Society 215
  Street-lighting Reconstruction Problems, by L. Gaster 225
  Lambert and Photometry, by A. P. Trotter 313
  Notes on Events during the Vacation, by L. Gaster 316
  The Position of the Metal Filament Lamp and Fittings Industry at the Present Time 319
  The Sheringham Daylight, by L. C. Martin 323
  A New Form of Photometer, by Haydn T. Harrison 328

J

James Watt Centenary, The 172
Japanese Illuminating Engineering Society, The 26, 268

L

Laboratories and Colleges, Lighting of .. 4, 13
Lambert and Photometry, by A. P. Trotter 313
Lamp, A New High Voltage Low candlepower 296
Lighting Calculations, A Chart to facilitate 192
Lighting Restrictions in Paris 285
Lighting Vulgarities 300
London " Safety First " Council, The 17, 18, 340

M

Mesothorium as a Substitute for Radium in Luminous Paint 109
Metal Filament Lamps and Fittings Industry, Present position of 319
Mine Lighting and Safety 136
Mobile Lighting Sets 340

N

PAGE

National Physical Laboratory, Annual Visit to 171
Niagara Falls, Flood-lighting of.. .. 340

O

Obituaries—
  Sir Wm. Crookes 105
  Sir Boverton Redwood 172
  Professor A. G. Vernon Harcourt .. 214
  Mr. S. D. Chalmers 315
Office Lighting, Modern Practice in, by A. Wise 21, 27
Overhead Adjustable Fittings 299
Overseas Trade and the Press .. 92,107

P

Paris, Street Lighting in War Time .. 293
Patent Office Library, Extension of Hours of Entry 350
Personal Notes 110, 136, 305
Photometer, A New Form of, by Haydn T. Harrison 328
Pointolite Lamps, New Types of, by P. Freedman 324
Police, Light as an Aid to 293
Public Lighting, London " Safety First " Council's Recommendations on .. 17
Public and Private Lighting, Co-operation in (Editorial) 204
Public and Private Lighting, Recent Developments in, by W. C. Clinton .. 287

R

Railway Lighting (Editorial) 53
Railway Lighting and its Maintenance, Some Notes on, by A. Cunnington .. 59
Railway Lighting, Joint Committee on.. 318
Reflectors with White Diffusing Surfaces 267
Research Laboratories for Works Organisations, Planning of, by A. P. M. Fleming 3, 9
Research Workers, The Supply of (Editorial) 116
REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED 19, 111, 135, 199, 277, 306, 329, 354
Royal Institute of Public Health, Brussels Congress 350
Royal Society, Conversazione 196

S

Safety, Good Lighting as an Aid to (Editorial) 242
San Francisco Harbour, Lighting of .. 110
Scientific Illumination, The Principles of, by G. E. Webb 195
Scientific Knowledge, Publicity for (Editorial) 279
Scientific Lighting and Industrial Efficiency, by L. Gaster 188

PAGE
Scientific War Time Public Lighting in Paris 293
Searchlights 52, 274, 331, 335
Selenium Cells, Use of as Safety Apparatus 104
Shadow, The Measurement of 344
Sheringham Daylight, The, by L. C. Martin 323
Short Sight in School Children 296
Shipping, Engineering and Machinery Exhibition, The 297
Shipyard Lighting, Emergency Methods in 272
Stage Lighting, The Art of, by J. B. Fagan 118
Stage Lighting, The Historical Development of 181
Standards for Gas on a Heat Energy Basis (Editorial) 115
Standard Specification for Tungsten Lamps, a Japanese 283
Street Safety and Lighting Conditions .. 340
Street Lighting, Improvements in .. 182
Street-lighting Reconstruction Problems, by L. Gaster 225
Street Lighting and Traffic Accidents, by Ward Harrison 286
Subways and Underground Passages, Lighting of 292, 338
Switching Requirements in Large Buildings 285

T

PAGE
Test Types for Vision, Illumination of.. 5
TOPICAL AND INDUSTRIAL SECTION 88, 136, 275, 174, 197, 301, 351
Training Ex-Soldiers in Engineering .. 350
Train Lighting for German Peace Delegates 187
Tungsten, Metallography of 110

U

Ultra-Violet Light Radiation from the Quartz Tube Mercury Vapour Lamps 7
Ultra-Violet Radiation, Special War Uses for 295
Underground Passages, Lighting of 292, 333, 338

V

Victory Loan, The (Editorial) 110

W

Water-Power in the British Empire .. 133
World Trade and the British Empire .. 173

X

X-Rays, Examination of Metals by .. 133

NOTICE.

Owing to the great demand for Back Numbers, the cost of Vols. I.—IX. will in future, and until further notice, be **20s.** UNBOUND, and **25s.** BOUND, to NON-SUBSCRIBERS.

YEARLY SUBSCRIBERS and MEMBERS of the ILLUMINATING ENGINEERING SOCIETY, however, can obtain these volumes at a cost of **17s. 6d.** UNBOUND, and **20s.** BOUND.

Special Cases for Vols. I.—XI. of "THE ILLUMINATING ENGINEER" will be supplied at a cost of **4s.** each by

THE ILLUMINATING ENGINEERING PUBLISHING CO., LTD.,
32 Victoria Street, London, S.W.1.

VACHER & SONS, LTD.
Westminster House,
Great Smith Street
S.W.1.—77833.

ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

Illuminating Engineering, 1914—1919.

It has been our custom, in our January issue, to review progress in illuminating engineering during the past year. While the war was in progress there were few developments to record, but with the cessation of hostilities there is a prospect of the resumption of more normal conditions. We may take this opportunity, therefore, of surveying some of the tendencies during the period 1914—1919, and considering the immediate future. The changes to which we refer may conveniently be grouped under seven main headings :—

(1) The *diminutions in street lighting*, which reached their maximum in 1918 and are now happily disappearing. This experience has confirmed the importance of good lighting in streets in the interests of safety, but may also have a salutary effect in leading the public to appreciate the fact that uniform diffusion of light may be more important than mere quantity of light, if glare is avoided.

(2) The enforced *economy in lighting*, which, while tending to produce a temporary diminution in the amount of light used, has led people to study lighting more closely and may, therefore, ultimately be favourable to a better appreciation of the principles of good lighting.

(3) The war has driven home the *necessity for co-operation and joint action*, and this may have an important effect in some fields of lighting, such as the promotion of uniformity of action in regard to street lighting, and the standardisation of voltages for lighting.

(4) The necessity of improving output in factories has stimulated interest in *industrial lighting* and has emphasised the close connection between lighting and output ; simultaneously the study of the health of munition workers has yielded confirmatory evidence of the importance of good factory lighting in the interests of health and safety.

(5) The *shortage in many essential commodities* at the outbreak of war revealed deficiencies in our manufacturing facilities which have since been largely remedied. While few important developments in lighting have been announced, facilities for the making of standard types of lamps and fittings have been improved and, with the removal of war conditions, new developments may be expected to follow.

(6) There has been a powerful movement towards a general recognition of the need for *better facilities for scientific research and technical education*, and especially the application of science to industry, as illustrated by the formation of the Department of Scientific and Industrial Research and the success of the British Scientific Products Exhibition. This general tendency will doubtless be reflected in illuminating engineering.

(7) While international congresses, and international co-operation in scientific matters have necessarily been in abeyance, common action has become essential among the Entente countries in connection with many problems and the settlement of peace. One can already foresee several problems involving the use of light where *international co-operation* will be necessary ; for example, the provision of lighting to facilitate air traffic by night and the requirement of good industrial illumination as one of the demands of the international labour conference now sitting.

In many directions, therefore, the trend of events should be helpful to progress in illuminating engineering. At the commencement of 1918 we celebrated, in our "Tenth Anniversary Issue," the termination of ten years of existence of THE ILLUMINATING ENGINEER. We are now just concluding ten years of existence of the Illuminating Engineering Society. Let us hope that the new decade will yield greater prosperity to both.

The Planning of Industrial Research Laboratories.

The interesting paper read by Mr. A. P. M. Fleming in his recent paper before the Institution of Electrical Engineers, to which we refer in the present issue (pp. 9—12), dealt with a subject of vital importance. Industrial research laboratories may be of many kinds. They may be associated with individual works, groups of factories, or associations of manufacturers. In some cases different types, run by the same company, may work hand in hand, as, for example, the N.E.L.A. laboratory at Cleveland, Ohio, which deals with general research problems, and the more industrialised laboratory at Schenectady, which is mainly concerned with technical and manufacturing problems. Of great interest, also, is the "experimental factory" where promising inventions can be tested on a commercial scale, thus preventing disappointment and encouraging manufacturers to take up immature but hopeful inventions which require commercialisation.

Mr. Fleming also deals with the training of the research staff. We entirely agree with his insistence on the need for scientific attainments and University training on such a staff. Such qualifications, however, can only be secured if they are rewarded by corresponding remuneration. There must be as good prospects of advancement as exist in any other department of the firm's work, and a proper recognition of the valuable work that such a research staff can do. Otherwise, gifted men will not be attracted to this branch of work.

As Mr. Fleming remarks, in any case the demand for competent investigators and directors of research is likely to exceed the supply for some time to come. For the present we must look mainly to our universities and technical institutions. At some of the northern universities industrial research of a high value is already carried on, though naturally some of the work can hardly as yet be developed on a commercial scale. During the writer's visit to some of these universities in 1916 he saw much evidence of valuable researches of this type, and these institutions may offer a valuable recruiting ground for trained investigators. The ideal qualifications for a director of research can, however, only be evolved gradually. We imagine that it will be necessary either to take able men of high scientific attainments from the universities and afford them opportunities of studying the industry with which they are to be associated, or, conversely, to take suitable men already engaged in the industry and transfer them to a university for additional scientific training as a preliminary to entering on their duties as directors.

In conclusion, we should like to emphasise some of the suggestions made by Mr. Fleming in the final part of his paper. We agree that the cost of equipment and maintenance of a research laboratory is of small moment in comparison with the valuable results obtained for industry—for example, in lessening the cost of manufacture creating entirely new products, and acquiring general scientific knowledge which may have valuable future applications. We should also like to associate ourselves with Mr. Fleming's suggestion that undue secrecy regarding the publication of the results of scientific researches should be avoided. The war has illustrated in many ways the advantage of pooling such knowledge, and, while rightly looking first to their own advancement, firms should also give a thought to the interests of the community and co-operate in the solution of problems which are being studied by the industry as a whole.

The Lighting of Research Laboratories, Colleges and Technical Institutions.

We are very glad to note that Mr. Fleming laid stress on the proper lighting of research works (both natural and artificial). In the course of his paper it was naturally only possible to refer to the matter in very general terms, but an article in our present number (pp. 13—16) makes some useful further suggestions. The problems met with in research laboratories are broadly similar to those encountered in scientific colleges and technical institutions. We have often pointed out that illuminating engineering is a much neglected subject at our leading universities. In some cases care has been given to the lighting, but in others it is still carried out in a perfunctory and rule of thumb manner. In reality the technical institutions ought to give a lead in this matter. If, as we hope will be the case in the future, there existed at such institutions a Department of Illuminating Engineering, it would be impossible for the lighting to be overlooked. The planning and supervision of the illumination would furnish excellent practical work for students, working under the supervision of the staff, and the lighting arrangements would give evidence of care and originality—would, in fact, furnish useful suggestions to the outside world. At the present time there is ample scope for such illuminating engineering courses. There is a widespread demand for better methods of illumination, and during the last ten years a great deal of useful information, on which such courses could be based, has been acquired.

In scientific work the proper adaptation of the lighting to the purpose in view is of quite exceptional importance. The bulk of the work requires careful study of objects by investigators; they are using their eyes for observation continually. In every case, therefore, the particular form of lighting suited to the experiments should be studied. It is quite impossible to lay down hard and fast rules for lighting in laboratories. The conditions in chemical and physical laboratories are different, while in the special forms of workshops, and in rooms where particular industrial processes are studied, new problems in lighting continually arise. A research works or college has special facilities for dealing with these matters; it can produce in its own workshops any special fitting that may be needed; it has, or should have, the staff to make intelligent use of existing devices in practice, and, if necessary, to create new designs. In lecture theatres and class-rooms it is easier to suggest general rules, many of which are substantially the same as those formulated by the committee of the Illuminating Engineering Society in their report on "The Artificial Lighting of Schools" shortly before the war. Even here, however, conditions vary much in different buildings, and the best results are secured when the architectural features of the room and the lighting are considered simultaneously.

The problem which we are dealing with here is one that is attracting attention in other countries. We quote in this issue a letter from Sig. Peri, of Milan, pleading for courses in illuminating engineeing at technical colleges in Italy. We also reproduce some data furnished by a contributor now serving with the Forces of Occupation, regarding the lighting arrangements and general equipment of the classrooms attached to a factory in German territory. It should be our aim to secure for illuminating engineering a much more important place in the courses of study at our leading research institutions and colleges in this country so that the industries may look to them for guidance in matters of lighting, instead of wondering at the obsolete methods employed. Proper methods of lighting constitute a valuable asset and should be encouraged in every possible way.

LEON GASTER

REPORT ON STANDARD ILLUMINATION OF SNELLEN'S TYPES USED IN TESTING THE VISION OF CANDIDATES FOR PUBLIC SERVICES.

Issued by the Council of British Ophthalmologists, and Published in the "British Journal of Ophthalmology."

An interesting report on the above subject, issued by the Council of British Ophthalmologists has recently appeared. The Report was prepared as a result of a joint committee consisting of:—Sir George Berry (Chairman), Sir Richard Glazebrook, C.B., F.R.S. (Director of the National Physical Laboratory), Mr. C. C. Paterson, O.B.E. (National Physical Laboratory), Mr. Leon Gaster (Hon. Secretary of the Illuminating Engineering Society), Mr. J. Herbert Fisher, Col. J. Herbert Parsons, Mr. A. B. Cridland and Mr. W. H. MacMullen, O.B.E.

In what follows we give the substance of this report, which is of considerable interest to illuminating engineers:—

The effect upon visual acuity of variations in the illumination of test objects has been the subject of a series of careful investigations since the time of Tobias Mayer (1754). Two chief facts emerge from these researches: (1) that there is a rapid rise in acuity as the illumination is increased from zero up to about two foot-candles;* (2) that above two or three foot-candles there is scarcely any appreciable rise in acuity. The results obtained by different observers are not entirely concordant, the discrepancies being attributable to variations in the test object, contrast, size of pupil, etc. So far as the testing of visual acuity for clinical purposes is concerned, it appears to be sufficiently accurate to regard the results obtained with an illumination of three foot-candles or more as valid and comparable under the ordinary conditions of clinical testing.

There is, however, no doubt that this minimum is by no means always ensured under the actual conditions in which the testing of candidates for military or other public services occurs. Apart from the fact, which should be borne in mind, that the test types often do not conform to Snellen's criteria, they are frequently dirty, thus diminishing contrast, are varnished, thus giving rise to disturbing direct reflection of light, and are viewed under very great variations of daylight, in rooms which are often ill-suited for the purpose.

It is possible to lay down precise and simple rules for the efficient illumination of test types, and we see no reason why these rules should not be generally adopted. For the public services it is in our opinion unfair to the candidates and detrimental to the services themselves that the examinations should take place under unsatisfactory, and often hurriedly improvised, conditions. The testing of visual capacity is now an essential part of the physical examination of candidates for a large number of the public services, such as the Navy, the Army, the Mercantile Marine, the Indian Civil Service, and so on. We are of opinion that these tests should be conducted under approved conditions, and that this object would be best attained if the examinations were held at properly equipped centres.

We fully recognise that variations of visual acuity arise from many causes other than the actual illumination of the test types, such as the condition of retinal adaptation, contrast between the test object and its background, the size of the pupil, lateral illumination, and so on. We think, however, that these effects can be minimised sufficiently for practical clinical purposes if the testing takes place in a moderately well illuminated room, with the test types efficiently lighted, and with the careful elimination of any glaring lights or bright objects from the candidate's field of vision.

---

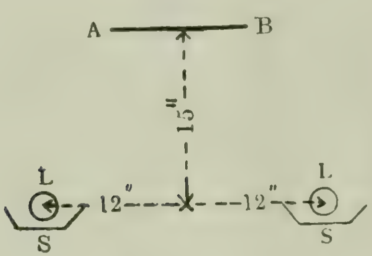
* One foot-candle is the illumination received from a source of one candlepower falling perpendicularly on a surface at a distance of one foot from the source.

We consider that the requirements are sufficiently well-satisfied by the following means :—

Two ordinary 20-watt tungsten lamps with straight filaments are fixed vertically 15 inches in front of the place of the test card, one on each side, at a horizontal distance of 12 inches from the vertical plane normal to and bisecting the card. One lamp is placed higher than the other, one being opposite the junction of the upper and middle thirds of the card, the other opposite the junction of the middle and lower thirds. Opaque non-reflecting screens are fitted, so as to prevent direct light from the lamps reaching the candidate's eyes.

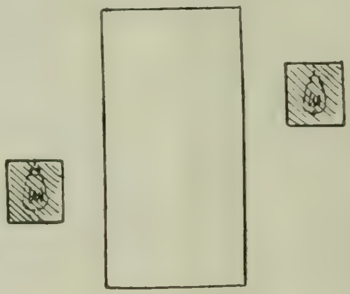
The accompanying diagrams illustrate the arrangement recommended.

PLAN.



A, B = Test Card.
L, L = Lamps.
S, S = Screens lined with matt black.

FRONT VIEW.



This method ensures :—

(1) Sufficient illumination. With new lamps the illumination on the test types will be of the order of 10 foot-candles. The ordinary variations of current, deterioration of lamps, and the darkening of the test card with age will not reduce the brightness of the test card so illuminated to a value less than that of a perfectly white surface receiving an illumination of 3 foot-candles.

(2) Sufficient uniformity of illumination. Whilst we are aware that the same result can be achieved by the employment of properly designed and carefully placed reflectors, we have had to recognise in making these proposals that the testing of visual acuity must often be carried out in circumstances which do not admit of the use of special lighting arrangements, requiring technical skill in their installation or upkeep. We have, therefore, endeavoured to prescribe a method of ensuring the necessary illumination which is simple to erect, is not liable to become deranged by subsequent treatment, and which enables ordinary lamps on the market to be employed.

Where electric light is not available a similar arrangement can be installed, using other illuminants (*see* appendix).

Daylight Illumination.—There is no theoretical objection to the use of diffuse daylight so long as the illumination on the test types is adequate, *i.e.*, does not fall below 3 foot-candles. In cases of doubt it would be necessary to apply tests requiring the skilled use of some form of photometer. We are therefore of opinion that, in order to secure uniformity and comparable results, artificial illumination should in general be used, and invariably in testing for the public services.

We therefore make the following recommendations :—

I. *The Test Types.*—The test types shall be of the dimensions laid down by Snellen, and printed on a matt white surface.

II. *Illumination* :—

(*a*) The minimum illumination on the test card shall be such that its brightness shall be equivalent to that of a new card illuminated to at least 3 foot-candles.

(*b*) The illumination of the test types shall be as uniform as possible.

(*c*) Artificial illumination shall be used in preference to daylight.

(*d*) The testing room shall be moderately illuminated, and care shall be taken that there are no glaring lights or bright objects in the candidate's field of vision.

(*e*) Extreme contrast between the illuminated test card and the background shall be avoided.

III. *Method of Lighting* :—

(*a*) The method of lighting described in this report shall be in general adopted.

(*b*) This method shall be made compulsory for sight testing in all public services.

Appendix.—Illumination of Test Types by Gas or Oil Lamps.

Gas Lighting.—Two "medium" inverted incandescent burners, consuming $2\frac{1}{2}$—$2\frac{3}{4}$ cub. ft. of gas per hour, are fixed $2\frac{1}{2}$ ft. in front of the test card, one on each side, at a horizontal distance of 12 inches from the vertical plane, normal to and bisecting the card. One burner should be higher than the other, one being opposite the junction of the upper and middle thirds of the card, the other opposite the junction of the middle and lower thirds. Burners should be equipped with clear glass globes, and care should be taken to ensure, by regular maintenance, that mantles and burners are kept in good order and in clean condition. Opaque non-reflecting screens are fitted, so as to prevent direct light from the burners reaching the candidate's eyes.

Oil Lighting.—Two standard "Duplex" oil lamps, each having a double straight wick, 1 inch in width, and a chimney $10\frac{1}{2}$ inches in length, are fixed 2 ft. in front of the test card, one on each side, at a horizontal distance of 12 inches from the vertical plane, normal to and bisecting the card. One lamp should be higher than the other; one being opposite the junction of the upper and middle thirds of the card, the other opposite the junction of the middle and lower thirds. The wick should be turned up as high as is possible without smoking, and the face of the wick should be turned towards the card. The distance from top of wick to level of oil in reservoir should not exceed 5 inches. The lamp should be lighted 20 minutes before the test, so as to ensure steady conditions of burning. Opaque non-reflecting screens are fitted, so as to prevent direct light from the lamps reaching the candidate's eyes.

ULTRA-VIOLET RADIATION FROM THE QUARTZ TUBE MERCURY VAPOUR LAMP.

In a recent bulletin issued by the Bureau of Standards, Washington, Messrs. W. W. Coblentz, M. B. Long and H. Kahler describe some experiments on the quartz tube mercury vapour lamp. The chief object of the investigation was to ascertain the variation in the intensity of radiation, both total and ultra-violet, during the life of the lamp. The intensities were measured radiometrically by means of a bismuth-silver thermophile and auxiliary galvanometer. A water cell 1 cm. thick with quartz windows was used in front of the thermophile to absorb the infra-red rays of long wave length emitted by the electrodes and surroundings. The decrease in ultra-violet rays was determined by observing the change in transmission of a yellow (Corning Noviol) glass. It was found that the transmission of this glass did not vary appreciably with the power put into the lamp. Hence any change in the transmission of the glass is attributable to variations in the emission of ultra-violet rays.

By this means it was established that the ultra-violet rays emitted from quartz mercury vapour lamps decreases from an initial value of about 70 per cent. of the total radiation when the lamp is new to 50 per cent. after 1,000 to 1,200 hours' usage. This diminution in the ultra-violet energy is ascribed to the progressive discoloration of the quartz envelope due to the action of these rays. During the first 500 hours' usage no marked difference was observed in the percentage of ultra-violet emitted by these lamps. The total radiation decreased by one half to one-third of the initial value during 1,000 to 1,200 hours.

A diagram is given illustrating the variation in illumination at different inclinations with the axis of the tube: this, as might be expected, is a maximum in a direction perpendicular to the axis of the lamp and diminishes nearly to zero in directions facing its two extremities. Some data are also given showing the intensity of radiation received through glasses of different colours when the energy given to the lamp is increased; there is evidence of an appreciable increase in the percentage of red rays, though these always form a very small fraction of the total energy. A chart is also presented showing the distribution of energy through the spectrum of the lamp. A comparison is also made of the radiation of the lamp with solar radiation, whence it appears the portion of the total energy concentrated between 0 and 0·45μ is considerably greater in the case of the mercury lamp, namely, 20 per cent. as compared with only 5 per cent. for solar radiation.

THE BRITISH SCIENCE GUILD DINNER.

AT a meeting given by the British Science Guild at Prince's Restaurant on January 15th a tribute was paid to the success of the British Scientific Products Exhibition arranged by the Guild in 1918, which, it is satisfactory to learn, is to be repeated on a larger scale in the present year.

The Marquess of Crewe, who presided, alluded to the pioneering work done by the Guild and uttered a warning against the impression that science was necessarily an aggressive weapon. It had been put to a wrong purpose by our enemies, but it should be our task to show that, rightly used, it would be a great boon to mankind. The Marquess of Crewe also recalled that he had been responsible for initiating the Department of Scientific and Industrial Research, and expressed his conviction of the necessity of fuller facilities for high scientific education Lord Sydenham, replying to the toast, gave the history of a number of promising inventions which had been made in this country, but subsequently developed abroad. One of the objects of the British Scientific Products Exhibition had been to demonstrate to manufacturers what scientific research could do for industry. In the coming period of reconstruction science, properly applied, would prove of great benefit to the industrial prosperity of the country.

Mr. F. G. Kellaway, M.P., in proposing the "Exhibitions of 1918 and 1919" mentioned a number of problems that had been successfully solved by British men of science since the outbreak of war, including several ingenious methods of locating and attacking hostile aircraft. As instances of industries in which great progress had been made he cited the manufacture of magnetos, optical glass, and the use of mica in electrical work. Sir Robert Hadfield replying, described some of the achievements of the steel industry during the war, such as the manufacture of 18 in. shells, the largest projectiles used in the war. He mentioned that the Exhibition had attracted more than 30,000 visitors in London and 15,000 in Manchester, and referred in appreciatory terms to the services of those who had contributed to its success, including Professor R. A Gregory, the Chairman of the Organising Committee and Mr. F. S. Spiers the Secretary.

Mr. Charles F. Higham, M.P., in proposing "The Donors to the Exhibition Fund," expressed the hope that even more generous support would be forthcoming during the present year, and Mr. D. Milne Watson, in responding to the toast, strongly emphasised the vital importance of scientific methods of test in improving the quality of manufactured products, quoting, in this connection, some of his experiences in the ammonia soda industry.

A vote of thanks to the Chairman, proposed by Professor D'Arcy Thompson, terminated the proceedings. A representative gathering of over 150 members of manufacturing firms and men of science associated with the work of the Guild and the British Scientific Products Exhibition assembled for the dinner and the prospects of the 1919 exhibition appear very hopeful.

THE PLANNING OF A WORKS RESEARCH ORGANISATION.*

By A. P. M. FLEMING.

SCIENTIFIC research is destined to play a great part in the development of industry. During recent years many centres for research have been established. A distinction must, however, be drawn between research work in pure science and that bearing directly on industry. A certain amount of the latter kind of work is done at technical colleges and universities, and the Department of Scientific and Industrial Research is endeavouring to establish co-operative research in various industries. It is clear, however, that in many cases factories, or groups of factories, engaged in similar operations, will need to establish their own research laboratories. The purpose of the paper is to outline the scope of such an industrial research organisation, including the planning and equipment of the works and the choice of staff.

Functions of Research Laboratories.

Research laboratories wholly or partly supported by industrial firms may include: (1) Industrial research laboratories self-contained and serving one particular works; (2) central industrial laboratories serving as a centralisation of investigations on behalf of an industrial organisation, comprising several works, often in different industries, and linked up by control laboratories at individual works; (3) laboratories planned to serve a wide range of interests in various industries in connection with isolated problems (such as the Mellon Institute, U.S.A.); (4) laboratories designed to serve the needs of one particular industry working on a co-operative basis, and (5) State laboratories, such as the National Physical Laboratory and the Bureau of Standards (U.S.A.), and the various university laboratories.

The functions of an industrial research laboratory cover a wide ground. Mr. Fleming illustrated this by quoting twelve main lines of investigation, including such matters as testing raw materials, studying manufacturing processes and difficulties, developing new tools, new and improved processes, or underlying scientific phenomena, investigations for financiers of the possibilities of new projects of a scientific nature. This division was further illustrated by a large number of different sections (chemical, mechanical, testing, electrical, optical, illuminating, etc.) which may enter, to a varying degree, into different industries. An important function is also the development of promising inventions on a semi-manufacturing scale, in order to prove their commercial utility, which involves the use of what may be termed an experimental factory. Another section of great consequence is that concerned with the collection of intelligence and information. This entails a thoroughly equipped technical library where a trained staff can quickly collect for the experimental workers any information which they require in their researches.

Nature of Staff.

In discussing administration Mr. Fleming pointed out the need for frequent conferences between departmental chiefs in order that their mutual knowledge and experience may be pooled and overlapping of work avoided. The Director must possess very special qualifications. Besides high scientific attainments he must possess foresight and quick recognition of the possibilities of applying scientific knowledge to industrial problems, must be able to direct specialised research workers, and must have considerable organising ability and a thorough knowledge of the manufacturing processes in the industry concerned. The sectional heads must in general be men of high scientific standing. These, and the senior staff, should be men of university education and training.

---

*Abstract of a Paper read before the Institution of Electrical Engineers.

The question of the training of all concerned with the research department requires consideration. They may be men who are familiar with the particular work carried on, and who have subsequently been trained at universities; or, conversely, they may be men with scientific knowledge acquired at universities who have afterwards been afforded an opportunity of studying the work undertaken before entering upon their research duties.

With the exception of those engaged in actually directing research the staff should consist of comparatively young men, able to observe keenly, possessing sound technical training, and with some aptitude for research. On the other hand, the desired qualities are largely a matter of training. This class of worker need not necessarily be a genius—in fact there is much in the operation of an industrial research laboratory that is uncongenial to the genius type. The junior workers will be drawn largely from technical colleges, but it is probable that for some time to come the demand will exceed the supply.

Design and Equipment of Buildings.

In order to illustrate the design and equipment of an industrial laboratory Mr. Fleming referred to several well-known institutions in the United States and elsewhere. The average active working area (*i.e.*, floor area actually required for working) varies from 150—250 square feet per employee. In some sections, where the equipment is on a large scale, a greater area is needed, and in general it will be better to allow additional space for extensions. Thus 400 sq. ft. per worker, a value often met with in the United States, is not excessive. To the total space thus allowed must be added 10—20 per cent. for stores, lavatories, etc.

As regards the type of building:—

(1) For a gross floor area up to 6,000 sq. ft. a single story building of rectangular form in plan is preferred.

(2) For a gross floor area of from 6,000—12,000 sq. ft. the building may be either:—

(*a*) Single story, equivalent to two buildings of the type referred to under (1).

(*b*) A two-story rectangular building.

(3) For a floor area exceeding 12,000 sq. ft. a multi-story building is necessary.

The cost of type (2) (*a*) is in general 4—8 per cent. higher than for type (2) (*b*). For a single floor building either a brick or a reinforced concrete frame and brick fabric is recommended. The latter is cheaper and lends itself to more effective lateral lighting. A flat roof has much to recommend it; it facilitates subdivision of the building in sections, offers no exposed parts to corrosion, and both first cost and maintenance cost are low; it secures the most equable temperature and is favourable to artificial lighting. A flat roof also offers supplementary space as a testing area.

The elimination of vibration is an important factor in many laboratories, and a reinforced concrete skeleton and flooring, on account of its monolithic character, is favourable in this respect. Other special measures to avoid vibration are needed. Unbalanced machinery should be isolated, and preferably situated outside the main building; apparatus to be guarded against vibration should be situated on rigid tables, themselves protected from the conveyance of external vibration. In some special cases tables with rubber feet have been mounted on piers rising direct from the common foundation.

Lighting.

Lighting deserves special attention on account of the close and accurate observation necessary in a research laboratory. The relative values of vertical and horizontal illumination should be born in mind; the former is most important when objects are surveyed horizontally, the most usual case, the latter when surfaces are viewed from above. In this connection some diagrams are given showing the variation of daylight illumination in a horizontal plane 3 ft. above floor level, with various arrangements of windows. Lateral lighting, provided it is adequate, is to be preferred for general work. Top lighting in general means high horizontal illumination but unevenly distributed vertical illumination. The saw-tooth type of roof seems to give the most even distribution, especially if assisted by lateral lighting; this kind of roof, with a north light, excludes direct sunlight. The extent of window opening area should be 20—35 per cent. of the gross floor area, and liberality in this respect is a feature of modern factories.

For artificial lighting the author recommends diffused conditions, such as those presented by semi-indirect lighting, with white ceilings and light-tinted walls. Laboratories, libraries and workshops require normally an intensity of 3—6 foot-candles, although for special work, for which local special units may be installed, the required intensity may be as high as 12 foot-candles. The total flux of light in lumens required by a room is conveniently obtained by dividing the product of the floor area and the intensity of illumination by a "utilisation factor." Assuming light walls and ceilings this factor has the values 0·4, 0·5 and 0·6 for small, medium and large rooms, with direct lighting; for semi-indirect lighting the factors should be reduced by 33 per cent. Finally, the total lumens thus deduced should be increased by 20 per cent. so as to make allowance for depreciation due to dust, etc.

An indication of the spacing to yield fairly uniform illumination is afforded by the following table:—

Source of illumination.	Spacing Distance. / Mounting height.
Prismatic or mirrored reflectors—	
Focussing	0·75
Intensive	1·25
Extensive	2
Opal bowls or domes enclosing glass units	1·67
Semi-indirect or indirect bowls ..	1·5

Knowing the total lumens needed and the requisite distance apart of units corresponding with these data and the dimensions of the room, the consumption of lamps of a given type is readily determined.

Heating, Ventilation, and Supplies of Gas and Electricity, etc.

In the next portion of the paper Mr. Fleming makes special reference to protection against fire, the arrangement of sections, heating and ventilations, and other special matters. For heating the low pressure hot water system is recommended. Hot water pipes carried round a room near the ceiling give good results and are preferable to radiators, which interfere with the placing of bench fixtures, etc. Attention is drawn to the need for full equipment in the form of supplies of gas, electricity and water throughout the building; in some cases various supplementary supplies, such as hydrogen and oxygen, compressed air, high pressure steam, are also led into the various rooms. Alternative systems of direct and alternating electric current are also desirable.

In some research institutions in the United States the facilities in this direction are very complete. Thus in one case, besides the various supplies mentioned above, different systems of piping conveying water from a number of different sources, for purposes of analysis, are included. (A point that seems worthy of attention in this connection is the method of distinguishing between the various pipes. We recall that in the institution referred to this distinction is effected by painting all the pipes in different colours—a step which is very helpful when repairs have to be executed or new junctions made).

For floors hard wood blocks treated and laid on concrete, tiles and special compositions are available; materials which are noisy or liable to crack should be avoided. Rounded corners are recommended in order to avoid accumulations of dust. Fume chamber construction receives special attention.

Costs of Erection.

Some data for the costs of erection of buildings of various sizes (based on pre-war figures) are presented. Thus the total capital outlay for a 6,000 sq. ft. building is estimated at £8,950, and the total annual maintenance, including salaries, at £8,700; while for a 52,000 sq. ft. multi-story building the corresponding figures are £71,400 and £75,500. The cost of the building itself is about half the total outlay. The author insists, however, that the initial cost and maintenance should be regarded as of small importance in comparison with the results to be attained, and that undue economy, either in providing the equipment of the building or in the maintenance and salaries, is a mistake. A wealthy industry can maintain an unassailable position most readily by improving its methods of manufacture through research, this being the only effective method of securing monopoly. It is an economic error to assume that the best method of increasing profits is to increase selling prices through trade combinations or other means of production. A much more logical method is to bring about the difference between manufacturing cost and selling price by reducing the cost of manufacture; and in this connection the possibilities of research are unlimited. Moreover, the advertising value of research should not be overlooked. The knowledge that a manufacturing firm employs scientific methods establishes in the public mind a feeling of confidence in the firm's products; similarly this may be a favourable factor in influencing investors.

Finally, the hope is expressed that firms undertaking research on a large scale will adopt a broad-minded policy in regard to the publication of a great deal of the results of their work. The tendency towards secrecy on the part of most British firms has been weakened during the war, when many otherwise rival firms have embarked upon similar kinds of new work, in which exchange of experience was beneficial. This practice of exchanging experience is of great importance in keeping all sections of an industry up-to-date and increasing its capacity in international competition.

CLASSROOM LIGHTING IN A FACTORY IN GERMANY.

A MEMBER of the forces of occupation sends us some interesting notes on the equipment of the classrooms in the technical department of a large factory in Germany. These classrooms are being used for educational purposes by the education department of the division. They are equipped with a 250-volt d.c. and 3-phase 400-volt supply, allowing respectively 30 and 50 amperes to be taken for experimental purposes. There is also a single phase 250-volt supply up to 30 amperes. The lecture bench is fitted with high and low pressure water, coal gas, hydrogen, etc.

The lighting of the rooms is of the semi-indirect type, the form of fitting being of a somewhat unusual type comprising glazed porcelain reflector and lower translucent bowl, the whole rendered dustproof by protecting glass. The ceiling and the walls from 12 ft. upwards are white so as to promote good diffusion. There is also special blackboard lighting from nine 60-watt lamps suspended from the ceiling with chains four feet from the top board and level with its top edge, the lamps being equipped with 45° angle reflectors. The board illumination is stated to be very even and the general effect of the lighting is pleasing and free from glare. For the indirect lighting four gas-filled 100 candlepower lamps are used, each with a separate switch.

One therefore gathers the impression that both the lighting and the experimental facilities have been the subject of careful design and our correspondent and his unit are fortunate in having at their disposal classrooms so well equipped for educational purposes. It will be noted that the classrooms are apparently a regular feature of the educational equipment of a German factory, and might well furnish a hint to many employers in this country who have not yet made the instruction of their employees the subject of similar careful study.

SOME SPECIAL PROBLEMS IN THE LIGHTING OF LABORATORIES AND TECHNICAL INSTITUTIONS.

By An Engineering Correspondent.

As one who passed through the courses at one of the largest engineering institutions in this country, and has subsequently lectured at a number, the writer has had occasion to observe the lighting of such buildings and of recognising how vastly the actual conditions fall short of the ideal. At a technical or engineering college, surely, if anywhere, the lighting should be done scientifically ; while not necessarily costly in equipment, it should be well adapted to the purposes it serves. That there is frequently still a lack of forethought and ingenuity shown in dealing with these problems is no doubt due to the familiar saying that "what is everybody's business is nobody's business." There is no department specifically charged with the duty of devising and supervising the lighting ; often it seems to be carried out without any consultation with the lecturers or researchers for whom it is intended.

Though there are distinguished exceptions the majority of such institutions are lighted on a more or less uniform plan. In the classrooms and laboratories simple pendant lamps with shallow conical reflectors are the rule ; with gas lighting the lamps and burners are likewise placed at uniform intervals in the various rooms, and here, too, imperfect shading is a common fault. In basement corridors long lines of electric lamps or burners without any shades whatever are sometimes seen. The maintenance is also not infrequently "nobody's business," and dirt-covered bulbs, broken mantles, and discoloured chimneys are allowed to remain for too long without attention.

In the college of the future, possessing an illuminating engineering department, these things would not be permitted. Such a department would superintend the original lighting plans, design any extensions in the installation, invite suggestions from the various lecturers and demonstrators regarding any desirable changes, and look after the maintenance. Such work would be excellent material for the students, working under supervision, and would carry them much further than the usual somewhat tedious conventional photometric tests on lamps and burners. Until such departments exist, however, the best that one can hope is that those responsible for individual departments will come to take a more lively interest in the illumination.

It is not proposed to discuss the more glaring faults in lighting, which any member of the Illuminating Engineering Society would recognise and for which he would readily suggest a remedy, but there are certain problems which afford more room for discussion.

Lecture Theatres.

The lecture theatre, where demonstrations and experiments play an important part, differs essentially from a classroom. The generally accepted principle is that the main illumination should be upon the lecture table, and the general illumination of a much lower value. This is the more justifiable because students in such a theatre do not require a great deal of light. Their chief occupation is to listen and observe and they only take a few notes from time to time ; a modern lecturer does not encourage continuous scribbling of notes. In the writer's opinion two foot-candles on the desks suffice for students' needs. Three foot-candles would be ample. More important factors are absence of glare and a clear view of the lecture table. The usual arrangement of ascending rows of seats also limits considerably the methods of lighting. As the higher rows approach near the ceiling it is best to avoid pendant fittings, except when there is ample room, even above the level of the top seats. When this is the case indirect lighting, with sources completely concealed, has advantages, but in some theatres lighted by inverted arcs the general level of lighting is too high, and the brightness of the illuminated ceiling is apt to be wearisome. One of the best systems of lighting the writer has observed consisted of direct lighting from units studded direct on the ceiling and equipped with translucent shades of very low luminosity. In some cases beams crossing the ceiling offer convenient projections between which such units can easily be mounted. In any case the aim should be to get the units high up ; a forest of pendant lights, even if not in the direct range of vision, is distracting. Bowl fittings mounted direct on the ceiling answer very well.

The separate lighting of the demonstration table is not a difficult problem. This, too, should be effected by powerful units placed high up and equipped with focussing opaque reflectors. On this table an illumination of quite ten foot-candles may be suggested. The table will also be provided with abundant local plugs or gas connections from which special local lighting can, if necessary, be derived.

Blackboard lighting is admittedly a difficulty. The general illumination in a lecture theatre lighted as described above will not be sufficient. Special local fittings for attachment to the top of the blackboard and almost in the same plane are not, in the writer's opinion, satisfactory. The rays of light reach the lower parts of the board at too oblique an angle to be really useful, and any particles of chalk adhering to the board diffuse this light, forming a species of luminous haze. Lighting by means of projector units placed on the lecture table has been suggested, but it is obvious that there would be danger of shadows from the lecturer's body and also probably inconvenient direct reflection to students in the upper benches. There seems little doubt that the units should be situated above the board, to clear the line of vision from the highest bench, and sufficiently far in front of it to give reasonably uniform illumination. At the same time this distance must not be too great, otherwise it may be difficult to avoid specular reflection. A possible rule is that the distance of the units from the plane of the board should be half the complete depth of the board, and the distance above as small as is possible without obstructing any student's view of it. In these circumstances tilted opaque parabolic reflectors (with semi-matt interior) will be suitable, the units being mounted on arms projecting from the wall above the board. The blackboard surface should preferably receive an illumination at least 50 per cent. above that prevailing throughout the room.

For classrooms of relatively small dimensions this special table and blackboard lighting is hardly necessary. The room can be conveniently lighted by semi-indirect methods and the general illumination will probably suffice. The ceilings of classrooms and lecture theatres should be white and the walls, from 4 feet above the floor upwards, covered with a light-coloured matt distemper.

Chemical Laboratories.

In the laboratory there is also every reason to avoid, so far as possible, low hanging lamps which may get in the way of apparatus. In general a high vertical illumination is important, as shelves, diagrams and vertical surfaces of apparatus require light. For this reason, and also because there is less reflection of light sources in the polished surfaces of bottles, etc., and less inconvenience from shadows in bending over work, the writer prefers semi-indirect methods. This is particularly the case in chemical laboratories, where the room is divided up by fairly close vertical shelves containing bottles which may throw inconvenient shadows from direct lights. In a chemical laboratory gas is indispensable at the benches for Bunsen burners, etc., so that gas may also be used as the illuminant. The same applies to rooms where gas furnaces are installed for metallurgical processes, etc. In the ordinary chemical laboratory a general illumination of 3—4 foot-candles, both on horizontal and vertical surfaces, should be aimed at. Balances and fume cupboards may require special lighting. In neither case is it desirable to instal a light inside, and it seems desirable to have a special local light directed from without. The figures on the shiny scales of balances are commonly hard to read. Professor J. T. Macgregor Morris has described the use of a local shaded unit placed on the top of the glass cover of the balance and supplemented by white cardboard screens which diffuse the light on to the scale and pointer.*

A question that deserves special consideration in a chemical laboratory is the colour of the light. In ordinary chemical work much depends on the observation of the colours of precipitates, the change in tint of "indicators" used in titrating solutions, etc. It is distinctly less easy, for example, to detect the delicate change in tint of methyl orange by artificial light than by daylight. When dyes are in question the appearance of colour is all important. It may be suggested, therefore, that in the chemical laboratory of the future the installation of something approaching "artificial daylight" might be considered, at least in rooms devoted to advanced work where colour is important. If this cannot be done, it might at least be possible to equip a booth in one corner of the room with an artificial daylight unit, to which colours can be referred when necessary.

The presence of acids and alkalis, fumes, etc., is often regarded as prejudicial to fittings in a chemical laboratory, and certainly this furnishes a reason for keeping fittings well out of the way of benches and avoiding flexible wire or easily corroded metal parts. But in a modern laboratory such corrosive effects should not be much in evidence; the right place for any vessel likely to develop fumes in any quantity is the stink-cupboard.

Electrical and Physical Laboratories.

In electrical and physical laboratories there is also every reason to prefer overhead lighting, so as to keep all fittings clear of the tables, which are usually fully occupied by apparatus. In electrical work a sort of false division in lighting has been brought about by the use of reflecting galvanometers. In order to watch the spot of light conveniently it was formerly considered necessary to leave the room in comparative darkness. More or less darkened rooms were devoted to experiments entailing the use of such apparatus, while rooms where work was done only with dial instruments rejoiced in a normal high illumination. Any attempt to work with both sorts of instruments in the same room was only possible by using local shaded lamps—a practice which it is desirable to avoid. If well diffused general lighting of 3—4 foot-candles is provided, however, it should now be possible, even in these circumstances, to use reflecting galvanometers, for with the modern focussing metal filament lamps (of the type used with motor-car headlights) and still more with such units as the pointolite lamp, it is usually practicable to produce a comparatively brilliant spot of light, which can be seen with ease in spite of the general illumination, especially if the scale on which the spot of light falls is hooded. The production of a brilliant but even spot of light is well worth study. Nevertheless, there are some instruments which necessarily use mirrors so small that only a feeble spot of light can be obtained. These should preferably be relegated to a semi-dark room, which is dependent on local lights.

A room of this kind is necessary in every research building where optical, photo-microscopical and photometric work is carried on. Manifestly photometric work cannot be done in a blaze of extraneous light. On the other hand, it may be argued that the darkening is often overdone, and that there is no objection to local lights being used in the room, provided they are properly shaded so that the rays cannot appreciably affect the photometric screen. Constant work in semi-darkness is admittedly depressing, and in colleges it is a common experience that students view with disfavour experiments that must be conducted in such circumstances. Another case where more or less feeble light seems inevitable is the smithy, or in rooms where work is done on glowing metal. It is not entirely the grime that renders the forge invariably a dark place, but rather that it is difficult to judge the exact condition of glowing metal if the general illumination is high. On the other hand, some operations, such as the observation of tempering tints, required artificial light, though here, again, the selection both of the colour and the intensity of the light requires care. The lighting of such places is, indeed, a matter that deserves fuller consideration; we have yet to determine the precise lighting conditions which enable obstacles on the floor to be detected and the outlines of adjacent objects to be clearly seen and yet do not interfere with the peculiar character of the work.

---

* ILLUM. ENG., Jan., 1916, p. 12.

The lighting conditions in workshops in research buildings are broadly similar to those met with in practice, and there is certainly much to be learned regarding the description of lighting best suited to different operations. In many testing workshops there will arise problems where some entirely novel method of lighting becomes necessary. These offer great scope for ingenuity and often illustrate forcibly the folly of assuming that all laboratories and workshops can be lighted on a uniform plan. In such cases the manufacturing resources of the workshops can often be used with advantage. It by no means follows that the solution of any particular lighting problem is best effected by the purchase of special lighting units. On the contrary, a home-made article, specially adapted to the end in view, is often the best solution, and the evolution of it is in itself an instructive lesson in illuminating engineering.

A PLEA FOR COURSES IN ILLUMINATING ENGINEERING AT TECHNICAL COLLEGES IN ITALY.

In a letter addressed to *L'Elettrotecnica* for January 25th, Sig. Guido Peri remarks that, among the other technical applications of electricity, the principles of illumination do not receive nearly as much attention as they deserve. Street lighting is still conducted in a crude and empirical manner, and companies concerned with the supply of electricity in general take little interest in such questions as the correct positions of lamps, the choice of globes and reflectors, and the specification of uniform standards of illumination according to the purpose for which the light is intended. The usual method in treating installations is to follow empirical rules based on candlepower in a horizontal direction, without due consideration of spherical or hemispherical candlepower. In particular it is rare for effective use to be made of a simple illumination photometer in studying the distribution of illumination in public and private lighting.

Bearing in mind the importance of illumination, Sig. Guido insists, engineers ought to be as fully conversant with the subject as with the mechanism of motors and dynamos. There ought, therefore, to be proper courses of instruction at all leading technical schools in illumination just in the same way as special instruction is given in telephony and telegraphy, electric traction, etc.

It is difficult to conceive of any application which is of greater value to humanity than the proper use of electric light, and it would be of great national benefit to encourage the study of the science and art of illumination.

CO-OPERATIVE METER READING.

In the United States it has recently been pointed out that much time and expense might be saved if the work of inspecting meters for gas and electricity, and the collection of accounts for these items, as well as telephone charges, water rates, etc., could be handled on a common basis, all being public utilities. In some cities in the United States, where all such commodities are publicly owned, there seems something to be said for the step; if one inspector could deal with the whole much time and labour could doubtless be saved. In this country, however, conditions are more complex, though there are doubtless some cases in which it might be considered.

LONDON "SAFETY FIRST" COUNCIL.

Recommendations on Public Lighting.

AT a meeting of the London "Safety First" Council, held on February 12th, a series of important resolutions emanating from the Street Lighting Sub-Committee were formally adopted.

The Street Lighting Sub-Committee had met on November 12th, 1918, to consider the situation in regard to street lighting which would arise in the event of an early cessation of hostilities, or after the conclusion of an armistice, whereby air-raids would cease and circumstances would permit of a return to better lighting conditions, subject to the continued need for fuel economy. An official announcement has been made sanctioning the removal of the masking of street lamps; the number of lamps in use, in view of the coal shortage, not to exceed one-half the normal. The regulations relating to the shading of lamps in shops and houses have been also withdrawn, although the prohibition of lights in shop windows and of advertisement lights is to be maintained at present on account of the coal shortage.

These changed conditions have been borne in mind by the Sub-Committee in framing their recommendations, which are presented in an official report issued by the Council, as follows:—

Lighting of Stopping Places for Tramcars and Omnibuses.

In view of the fact that, as a measure of economy, only 50 per cent. of normal lighting is at present to be restored, the Sub-Committee consider it desirable that, in placing public lamps out of service, strict regard should be paid to the safety of the public by retaining in service the lamps at regular stopping places for tramcars and omnibuses and other places where people congregate in numbers. Furthermore, it is suggested that, when buses take up passengers at points intermediate between regular stopping places, they should preferably do so at places in the vicinity of a lighted lamp, whereby passengers may be more easily distinguished and accidents avoided.

Diffusing of Light from Street Lamps and Avoidance of Glare.

The Sub-Committee have previously emphasised the importance of diffusing light from street lamps so as to screen the mantles or filaments from the view of drivers and pedestrians, thus avoiding glare and unduly sharp transitions from brightness to darkness on the roadway. The process of removing the masking of lamps is already being carried out; but it is suggested that, in cases where a light translucent white distemper has been applied in preference to dark bands, coloured lacquer, etc., the retention of such translucent coatings on lanterns might be encouraged for the present.

As regards permanent measures to be adopted for the future improvement of street lighting, attention may be drawn to the resolution adopted at the meeting on April 7th, 1918:—

> "That after the war, the use of appropriate reflectors designed on scientific principles should be encouraged, and that such appliances be designed to screen the naked lights of street lamps and to obviate the contrasts produced by alternating areas of brightness and obscurity in the roadway."

Meantime, with a view to promoting uniformity of illumination, it is recommended that when lamps containing two or more lamps or mantles are available, the diminution of 50 per cent. in the interest of economy of fuel should preferably be accomplished by extinguishing half the lamps or burners in every lantern rather than by completely extinguishing alternate lanterns and allowing others to show their full illuminating power.

Screening of Lamps in Shops and Private Houses.

Attention has also been drawn to the effect of exposed lamps inside buildings on traffic in the streets. Whilst the removal of opaque blinds covering lamps in shops, private houses, etc., will doubtless be beneficial in providing additional light for the roadway, there is a danger that the exhibition of naked lamps may prove distracting to drivers by reason of the contrast between such lamps and the relatively weakly illuminated street. It would, therefore, be desirable to encourage the use of translucent screens between such sources and the roadway, so as to diminish their intrinsic brilliancy and exercise a useful diffusing effect.

A further recommendation from the Street Safety Committee: "That a copy of the Report headed 'Lighting of Stopping Places for Tramcars and Omnibuses' be sent to local authorities and to the omnibus companies operating in the Greater London area," was adopted unanimously.

Other matters dealt with included the lighting of road obstructions. This has been referred to in a communication from the Chief Commissioner of Police in the Metropolis emphasising the desirability of a uniform practice. The suggestion is made that all road authorities in the Metropolitan area should require founderous places, newly filled trenches, unrolled road metal, etc., to be marked after dusk with red lights, which should indicate the extreme width of the obstruction and, in the case of lateral obstructions, should not be more than 4 ft. apart. The matter is to be the subject of further consultation.

The "Safety First" Movement and the Reduction of Accidents.

A bulletin issued by the London "Safety First" Council contains some striking figures, showing the good results obtained, both in this country and in the United States.

The "Safety First" campaign conducted by an important British Railway Company resulted in a reduction of accidents to employees by 16·2 per cent. and 10·9 per cent. in 1915 and 1916 respectively. An important Metropolitan Transportation undertaking, during the past five years, despite numerous adverse conditions, reduced accidents by 70·9 per cent. and compensation claims by 57 per cent. Street accidents, fatal and non-fatal, in the Greater London area were lessened by 18 per cent. in 1917.

Important results have also been obtained in many industrial undertakings. Thus it is recorded in a recent Government pamphlet that a large firm in the North of England reduced the number of accidents in its works by 65 per cent. in a single year, while premiums paid in respect of Employers' Liability and Workmen's Compensation have been reduced, in some instances by nearly 50 per cent.

These figures are sufficient to show the promise of the movement. The saving resulting from a scientific "Safety First" campaign may be expected to far exceed the expenditure involved. When it is recalled that in the year 1914, 969 persons were killed and 147,045 injured in accidents in factories and workshops alone, the possibilities of the movement will be seen. There is every reason to think that defective artificial lighting is a contributory cause of many such accidents and the London "Safety First" Council will, no doubt, include this aspect of accidents in their scheme of operations. It will be recalled that the question of industrial safety is now dealt with by the recently formed British Industrial Safety First Association, in which the Illuminating Engineering Society is appropriately represented.

MINISTRY OF MUNITIONS.

Calcium Carbide.

20th January, 1919. *Notice No.* 25.

In reference to the Calcium Carbide Order in 1917 and to the notice of the Ministry of Munitions issued in the Press and dated 26th November, 1918, fixing maximum prices and removing certain restrictions on dealings in calcium carbide: notice is hereby given by the Minister of Munitions that on and after the first day of February, 1919, the maximum prices for dealings in calcium carbide are amended, and shall be as follows for quantities of 110 lbs. and over, exclusive of carriage charges, namely:—

£30 per ton for lump sizes.

£30 10s. per ton for granulated sizes up to 15/25 mm.

Aluminium.

20th January, 1919. *Notice No.* 26

The price at which the Government are prepared to sell their stock of aluminium has been reduced to £150 per ton for 98-99 per cent. ingot at which price steps have been taken to stabilise the market. Arrangements have been made in regard to these stocks that they shall be disposed of in such a way as to avoid dislocation in the aluminium industry.

(End of Serial C.10332.)

ROYAL SANITARY INSTITUTE.

Courses of Lectures and Demonstrations.

The Royal Sanitary Institute send us particulars of their courses of lectures and demonstrations for the Spring Term, commencing Monday, February 17th, Friday, February 21st, and Monday, February 24th, 1919. The courses are intended for sanitary officers, women health visitors, tuberculosis visitors, school teachers and meat and food inspectors, and there are also special lectures for maternity and child welfare workers.

Fuller particulars can be obtained on application to the Secretary of the Royal Sanitary Institute, 90, Buckingham Palace Road, London, S.W.1.

We understand that the Institution of Civil Engineers, at a meeting held on January 28th, elected upon its roll of distinguished Honorary Members, Marshal Foch, O.M., Field-Marshal Sir Douglas Haig and Admiral Viscount Jellicoe, of Scapa, G.C.B., G.M.

INDEX, January, 1919.

PAGE
British Science Guild Dinner, The 8
Classroom Lighting in a Factory in Germany 12
Editorial. By L. GASTER 1
Illuminating Engineering Courses at Technical Colleges in Italy, A Plea for .. 16
Lighting of Laboratories and Technical Institutions. By AN ENGINEERING CORRESPONDENT 13
LONDON "SAFETY FIRST" COUNCIL :—
  Recommendations on Public Lighting 17
  The "Safety First" Movement and the Reduction of Accidents 18
Ministry of Munitions, Orders regarding price of Aluminium and Calcium Carbide 18
Planning of a Works Research Organisation. By A. P. M. FLEMING 9
REVIEWS OF BOOKS—
  The Electrical Engineer's Diary (1919) 19
  Gas and Gas-making, by W. H. Y. WEBBER—The Year Book of the Scientific and Learned Societies of Great Britain and Ireland—A Diary of Meetings of Scientific and Technical Societies—Journal of the Society of Glass Technology—Ways and Means. 20
Royal Sanitary Institute, Forthcoming Courses of Lectures and Demonstrations 18
Standard Illumination of Snellen's Types used in Testing the Vision of Candidates for Public Services. Report issued by the Council of British Ophthalmologists 5
Ultra-violet Radiation from the Quartz Tube Mercury Vapour Lamp, Diminution with Life 7

REVIEWS OF BOOKS.

Electrical Engineer's Diary for 1919. *Edited by J. H. Johnson.* (*S. Davis and Co.*, 31, *St. Swithin's Lane, London, E.C.* 430 *pp.* 7*s.* 6*d. post free*, 9*s. abroad*).

THE *Electrical Engineer's Diary* for 1919 makes a welcome appearance. Its size has increased somewhat, from 404 to 430 pages, and it contains the same useful features remarked on in previous years. It will be recalled that the Diary is conveniently divided into six main sections dealing respectively with the Conversion of Electricity, the Application of Electricity for Power Purposes, the Application of Electricity for Lighting Purposes, the Installation of Telephones and Bells, the Application of Electricity for Cooking and Heating, General Information. Each of these sections contains a large amount of condensed useful technical information, while in the general section the list of definitions of technical terms and the List of Streets covered by the mains of the chief metropolitan electric supply authorities have always struck us as very helpful.

The general contents of the Diary have not been greatly altered from those occurring in the 1918 issue. The section on lighting again contains the special treatment of industrial illumination, and we notice the insertion of a graphical explanation of the lumen. Other subjects which receive more attention are the use of gas fuel for steam raising plant, the application of pulverised coal and the operation of plants in oil vapour.

We are glad to note that the Diary has appeared with all its usual features throughout the war and, in view of the cessation of hostilities, it will doubtless make good progress in the future.

Gas and Gas Making, by W. H. Y. Webber. (Sir Isaac Pitman and Sons, Ltd., 1, Amen Corner, London, E.C.4. pp. 130. *2s. 6d. net.)*

THIS little volume forms one of the "Common Commodities and Industries" series, amongst which gas and gas-making takes a high place. The book is subdivided into twenty chapters. The early sections deal mainly with the history of gas production and the conditions under which the gas industry has developed in this country. Subsequently the author leads up to modern practice, and has much to say on the distribution and measurement of gas and its practical uses for heating and cooking and for illumination. The final chapter contains some useful hints to consumers. The treatment of the subject is quite simple, and even the non-technical public should be able to grasp something of the complexities underlying the choice of illuminating and calorific power, the general process by which gas is manufactured, and the nature of burners and heating appliances. The book seems a good example of a tendency to make technical things intelligible to the general public, which is certainly one to be recommended in these times.

The Year Book of the Scientific and Learned Societies of Great Britain and Ireland, Session 1917—1918. *(Chas. Griffin and Co., Ltd., Exeter Street, London, W.C 2. pp.* 333.)

THE thirty-fifth annual issue of this publication is a most useful production, both as regards its primary function of giving information regarding the chief scientific and learned societies of Great Britain and Ireland and for the record it provides of progress in this field. When one recalls that the record covers a period when the war was at its most severe stage, it is encouraging to observe how successfully all such societies have contrived to "carry on." The work is divided into 15 sections dealing respectively with science generally and with the chief subdivisions of science. In each case the address of the Society, its officers, particulars of its objects, times of meeting, etc., are briefly given, and a list of the most important papers read during the past session is appended. An index at the conclusion of the volume enables any society to be located under its appropriate heading. The book should be in the hands of all who wish to be conversant with the progress of science and the proceedings of the very large number of bodies which devote themselves to the study of one or more of its branches.

A Diary of Meetings of Scientific and Technical Societies.

A MONTHLY bulletin is now being issued by the Conjoint Board of Scientific Societies giving particulars of forthcoming meetings of scientific and technical societies, arranged in order of date. In view of the very large number of such gatherings, the bulletin should prove a most useful and convenient publication. The bulletin is under the editorial charge of Professor R. A. Gregory (*Nature* Office, St. Martin's Street, London, W.C. 2), to whom announcements of forthcoming meetings should be sent.

Journal of the Society of Glass Technology, December, 1918. *(Published quarterly by the Society of Glass Technology, the University, Sheffield).*

THIS volume contains particulars of several useful researches, including the Report of the Refractories Research and Specifications Committee and papers dealing with such subjects as Silica Refractories for Glassworks' Use, the Effect of Temperature on the Rate of Corrosion of Glass, Refractory Materials and the Glass Industry, the Requirements of Clay for Glasshouse Pots, etc.

At the end of the volume is the usual series of abstracts of current articles dealing with various aspects of glass technology.

"WAYS AND MEANS."

A Weekly Review of Industry, Trade, Commerce and Social Progress.

WE are informed that a new review under the above title is being issued by Messrs. Benn Bros., Ltd. The publication aims at meeting an admitted want by supplying a Review of Industry. It will, in fact, attempt to do for trade what the *Spectator* and the *Nation* do for politics.

The subjects to be considered cover a wide ground, some of the chief items being as follows: The Business Side of Parliament, the European Situation, Colonial Development, Industry and Money, Education, Industrial Administration, Wages and Profits. The Journal will also carry on the work on Industrial Reconstruction with which Mr. E. J. P. Benn has been associated in recent years, will deal with the applications of science to industry, and will include, as a special feature, a review of the Trade Press.

We think it will be generally admitted that there is an opening for a publication of this description and we wish the new venture every success.

·ELECTRICITY· ·ACETYLENE·
The
ILLUMINATING
ENGINEER
·OIL· ·GAS·
Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

Office Lighting.

The discussion on office lighting, opened by Mr. A. Wise at the meeting of the Illuminating Engineering Society on January 21st, raised a number of interesting problems. While there are certain fundamental principles which should govern office lighting in general, it must be understood that each case has to be treated on its merits. The conditions in a small private office are different from those prevailing in a large office, where there are many clerks engaged side by side on similar work ; banks, insurance offices, etc., present special problems ; and in rooms where work is not done entirely at fixed points, and vouchers, etc., have to be carried about and inspected at different parts of the room, special circumstances have again to be borne in mind. In the same way we hold that it is impracticable to suggest any particular system of lighting, whether direct, indirect or semi-indirect, for invariable use, though the general opinion at the meeting seemed to favour semi-indirect methods in most cases where the light requires to be spread evenly over the room as a whole. There is at the present time some vagueness in the manner in which these systems are defined, and it will be noted that the methods of classification proposed by various speakers are not quite in agreement. This is a matter which we think might fitly receive the attention of a small committee of the Society.

The suggestion made in the discussion that a committee should be appointed to draft some general recommendations on office lighting (similar to those already prepared in the past by the committees on school and library lighting) will be adopted in due course. There are many points, such as the provision of sufficient illumination, the avoidance of glare, the elimination of inconvenient shadows, and the use of light surfaces for walls and ceilings to diffuse the light, on which general agreement might be expected; and some guidance could also be afforded on such special problems as the lighting of typewriters, shelves and drawing offices. The Committee should therefore do useful work.

There are also various factors which, while not forming part of the essential scheme of lighting, have an important bearing on the results, such as the nature of walls and ceiling and the kind of paper employed for office work. Every lighting engineer will appreciate the great aid that can be obtained from light surroundings and wherever possible offices should be decorated with a light tinted matt surface, without shine. In the discussion frequent reference was made to the trouble experienced in reading some types of forms, vouchers, etc., scribbled in copying ink pencil on flimsy or shiny paper. While some help can be obtained by the judicious use of well-directed local lighting, it is evident that writing of this kind is almost invariably difficult to read, and firms would do well to dispense with this type of stationery.

Among the other points discussed were the desirable illumination for reading and writing and the special arrangements suitable for clerks in banks and insurance offices. We fully agree that the primary consideration is to provide sufficient illumination to work in ease and comfort and that money is well spent that secures these conditions. At the same time, if it is desired to recommend values of illumination much in excess of the 3—4 foot-candles commonly considered sufficient for reading and writing, data should be available to demonstrate that such values have been found advantageous and necessary in practice. It is quite probable that for the reading of handwriting, especially on paper which is not white, higher values may be needed. But this is a matter which will be settled by actual experiment. It is also clear that the requisite illumination depends in a great degree upon contrast, and this leads to another question, the choice between general illumination of a fairly high value and local illumination supplemented by moderate general lighting. In banks, as is well known, a preference for local lights has been found to exist, and opinion seems divided as to the advantages of the two systems for office use. It is sometimes contended that a certain amount of contrast between the brightly lighted paper and the relatively subdued surroundings is restful. But it is also generally agreed that the contrast should not be too great. Here, again, is a problem which awaits a definite solution and might well engage the attention of the committee of the Society.

To sum up, therefore, we find in the discussion evidence of some problems that require further elucidation but also of general principles on which there is agreement.

The latter might well be made more accessible to the public through the issue of a readable bulletin, and we hope that in the near future arrangements will be made for this to be done. What is needed is to bring home the conviction that proper lighting in the office is indispensable to expeditious and efficient work, and that the selection and placing of lighting units needs to be planned with care and forethought. During the war, as is well known, many buildings have been converted to office work at short notice and without the necessary rearrangement of lights; in such cases the conditions of illumination are sure to be faulty. Many forms of office work impose a severe tax on the eyes which is inevitably increased if the illumination is inadequate and badly arranged.

Illuminating Engineering Abroad.

While the war has been in progress there have naturally been few opportunities of studying the development of illuminating engineering abroad. The Society in the United States has steadily pursued its work, but in most of the belligerent countries the movement may be said to have marked time. Now that normal conditions are returning we may expect to see a recrudescence of activity, and we hope that in France, where steps were being taken towards the formation of an Illuminating Engineering Society before the war, the matter will be taken up *de novo*. In Russia, likewise, a movement towards the formation of a body to deal with lighting matters was initiated some years ago, but unhappily the subsequent political disturbances seem to have prevented this coming to fruition.

It is most interesting to observe, therefore, the successful formation of an Illuminating Engineering Society in Japan, to which we referred last year, and of which we give some particulars in the present number (p. 26). The Society already receives the support of over 600 members, an interesting feature being the existence of a special class of " sustaining members," similar to those in the American Society. The nature of such members requires a word of explanation. In the constitution of the American Society it is stated that a " sustaining member may be a company, firm, association, or individual interested in the objects of the Society and desirous of contributing to its support. A sustaining member, when other than an individual, may be officially represented by an individual. The privileges of sustaining members shall be the same as those of other members except the right to vote and hold office." We think that the knowledge that over 600 supporters (including 84 " sustaining members ") can be found for the movement in a distant country like Japan should be a stimulus to those associated with the Illuminating Engineering Society in this country, and we hope that it will assist towards the extension of membership which the Society in this country so badly needs. If a newly-formed society in Japan can gather this support, surely in this country, where the Society was started approximately ten years ago, a very much larger membership should be obtainable.

It is also a matter for consideration whether the time has not come for some " grouping " of our members. We should like to see, for example, facilities to allow the entrance of student members at lower fees than ordinary members. The whole question of the conditions of membership is one that will receive the consideration of the Council in the near future.

Another matter of great importance is the extension of the membership of the Society amongst those in other countries, and especially in the British Colonies and Dominions, who are interested in matters connected with illumination. The war has brought many engineers in the Colonial Forces in touch with developments in this country, and we observed with pleasure, in the recent lists of applicants for membership in the Society, the names of several who have served with the Canadian, Australian and other Expeditionary Forces. We hope that members will second the efforts of the Council by endeavouring to interest visitors from other parts of the Empire in the work of the Society, thereby providing a nucleus from which local branches of the Society may eventually be formed.

The Encouragement of Industrial Research.

An outline of the work of the Department for Scientific and Industrial Research was presented by Sir Frank Heath in his recent paper before the Royal Society of Arts. Considering that the Department was formed in war time, when its activities have been hampered in many ways, we think it will be agreed that a promising start has been made. The organisation set up has the advantage of elasticity, and it is at least a matter of consequence to have the machinery available for further effort. We have no doubt that with the return of more normal industrial conditions the Department will be able to extend considerably its useful work.

One of the chief channels for the encouragement of research is through the medium of the various research associations which are being formed in connection with the respective industries. We have before us a draft letter, issued by the Privy Council for Scientific and Industrial Research to such associations, outlining the conditions under which grants in aid of research can be made. Speaking generally, we think that no objection will be taken to the degree of State supervision involved. State-aided research differs in several respects from private enterprise. If the State is asked to grant money it is only natural that there should be some control of expenditure and machinery to ensure that the researches contemplated justify the support given. In a research having an industrial bearing this may fairly be required, although, in the field of pure science, the advantage of control is less manifest, and the highest forms of original scientific research depend essentially on the personality of the investigator whose efforts should not be unduly fettered.

There is, however, one clause (No. 8) in the letter to which reasonable exception might be taken by some, and which runs as follows :—

"The Association shall enter into an agreement in writing with each employee engaged on research or other scientific work that he will, in consideration of his employment, hold exclusively for the benefit and assign to the Association (and the Committee of Council of their nominees) at the cost of the Association, all rights and ownership in any discoveries, inventions, designs or other results arising in the course of such employment upon such research or scientific work."

It would appear that such an understanding might act as a deterrent to gifted investigators, who are thus debarred from a participating interest in any inventions or discoveries they may make, and who may, at the termination of their research work, find a difficulty of getting other employment. The salary which a research worker receives, or is likely to receive for some time to come, will not in itself prove sufficient inducement to devote a good portion of his life to such work, unless there is a prospect that he will ultimately receive, directly or indirectly, a share of the benefits arising from his researches. The effect of such an arrangement might therefore be to divert clever investigators into the services of enterprising private firms in preference to State-aided industrial research associations. It is possible that there are legal or other special circumstances which render a participation in the profits of inventions difficult to arrange in these cases. In the interest of industrial research and in order to remove any uncertainty regarding the prospects of men entering the service of such associations it would, however, be helpful if these important points could be cleared up.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

MODERN PRACTICE IN OFFICE LIGHTING.

Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, London, at 8 p.m., on Tuesday, January 21st, 1919.

A MEETING of the Society was held at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.), at 8 p.m. on Tuesday, January 21st, 1919, the PRESIDENT (Mr. A. P. Trotter) in the chair.

The minutes of the last meeting having been taken as read, the names of the following applicants for membership were next announced :—

CAINE, J. F. ..	Managing Director of the Britannia Lamp and Accessories Co., Ltd., 48, Milton Street, London, E.C.
CARTER, H. A. ..	Illuminating Engineering Dept., The General Electric Co., Ltd., 67, Queen Victoria Street, London, E.C.
HACKNEY, S. C. ..	Managing Director and Secretary of the Britannia Lamp and Accessories Co., Ltd., 48, Milton Street, London, E.C.
KING, A. W ..	Civil Engineer, 1, Clitheroe Road, Clapham, London, S.W.

The Hon. Secretary also read out the names of applicants for membership announced at the previous meeting of the Society* and these gentlemen were formally declared members.

The PRESIDENT then called upon Mr. A. WISE to read his paper, entitled "**Modern Practice in Office Lighting**" (see pp. 27—39). In the course of the paper Mr. WISE referred to the great importance of office lighting as an aid to the efficient and expeditious carrying on of work and to the need for careful planning and maintenance of such installations. A number of illustrations were presented, showing how offices of various types (private offices, banks, insurance offices, drawing offices, etc.) could best be lighted, and specific problems such as the lighting of shelves, typewriters, drawing offices, etc., were discussed in detail. In conclusion, Mr. WISE exhibited a special form of incandescent electric focus lamp which was intended for projection work with lanterns, etc.

An interesting discussion then ensued

---

* ILLUM. ENG., Nov., 1918, p. 249.

in which the following took part: Mr. F. W. Willcox, Mr. J. H. Jones, Mr. R. C. Bussell, Mr. F. S. Dennison, Mr. G. P. Garbett, Mr. O. L. Boyse, Mr. P. J. Waldram, Mr. J. S. Dow, and the President. The hope was expressed that the suggestions made in the paper might lead to the formulation of some definite general recommendations on office lighting by the Society.

Mr. A. Wise briefly replied to some of the points raised in the discussion, and in conclusion the President announced that the next meeting would take place at 8 p.m. on **Tuesday, February 25th**, when a paper entitled "**Some Notes on Railway Lighting and its Maintenance**" would be read by Mr. A. Cunnington (Lighting Engineer to the London and South Western Railway).

THE ILLUMINATING ENGINEERING SOCIETY IN JAPAN.

A reference was made last year to the foundation of the Illuminating Engineering Society in Japan, and some fuller particulars of its constitution and programme are now given in the Transactions of the Illuminating Engineering Society in the United States. The proposal to form the Japanese Society originated during 1914, and was renewed in the summer of 1916, finally coming to fruition in the autumn.

The Society now receives the support of over 600 members of all classes. Its first President is Dr. G. Yamakawa, Professor of Electrical Engineering at the Tokyo Imperial University, the two Vice-Presidents being Mr. Y. Shinjo and Dr. I. Nakahara, both of the Tokyo Electric Company. There are also forty-six councillors, from whom managers are selected by vote to conduct the Society's affairs.

The membership comprises four classes; honorary members elected in recognition of their high reputation in illuminating engineering; supporting members, who approve the principles of the Society and give it material support; regular members who have been educated at a college of standing or studied illuminating engineering or some kindred science, or have experience in the illuminating engineering arts or associated businesses; and associate members who are engaged in illuminating engineering works, or are connected with such business.

A set of nine forms of enterprises which the Society aims at pursuing is specified. These include the publication of transactions, lectures, committees on the standardisation of electric lamps, and nomenclature, the offer of prizes for designs of illuminating apparatus, a historical exhibition of lighting apparatus, public lectures on illumination, the initiation of series of measurements of illumination in representative buildings.

Members of the Illuminating Engineering Society in this country will join us in wishing the Society in Japan success and prosperity, and in expressing the hope that there will be fruitful opportunities for mutual co-operation between the Societies in America, in Japan, and in this country.

MODERN PRACTICE IN OFFICE LIGHTING.

By A. Wise.

(Paper presented at the meeting held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Tuesday, January 21st, 1919.)

Introduction.

Office lighting, like industrial lighting, is a subject of great importance, comprising many different problems. In both cases the conditions of illumination have an important bearing on the facility with which work can be done, and there is a close relation between illumination and productive power. It is naturally impossible, in the course of an evening's discussion, to cover this field completely. The object of the paper will be to suggest a number of debatable points for consideration, and to establish some of the fundamental principles of good office lighting. Many of the recommendations made by the Committees of the Society in regard to the lighting of schools and libraries apply here, although some are subject to modification according to the nature of the office to be lighted.

It will be convenient to consider first the choice of methods of lighting, next to consider how these can be applied to various types of offices. Subsequently we shall discuss one or two special problems met with in offices, and certain general considerations such as the importance of cleanliness of lamps and fittings and its effect on efficiency. Finally some typical examples of installations will be given.

Choice of System.

As in other lighting problems we have a broad division into general lighting, where every part of an office is lighted equally well; and local lighting, where an attempt is made to meet the needs of individual workers by sources placed in the right position to illuminate their respective desks, typewriters, etc. Assuming that general lighting is employed, we have a further choice between direct, indirect and semi-indirect lighting. The selection of local or general lighting naturally depends to a large extent on the size of the office. It is undoubtedly the easiest plan to illuminate the room as a whole with an illumination of sufficient intensity and of a well-diffused character, and when we are dealing with large rooms, where a large area is occupied by desks at uniform intervals, there is much to recommend this method. But it requires good diffusion, in which the reflection of light from walls and ceilings should play an important point, to ensure that no worker is inconvenienced by shadows. On the other hand, in small rooms especially, where we have only to consider the needs of one or two workers, there is much to be said for the practice of providing illumination for each exactly adjusted to his needs. If general lighting is adopted the smallest lamp that can be conveniently used to give a satisfactory light is the 100-watt type; thus if there are only two workers this works out at the somewhat extravagant figure of 50 watts per person. Similarly when general lighting is installed it will frequently happen that only one or two of the staff may be working late, and it is inadvisable to light a large area for their benefit with the full working intensity. This emphasises the importance of adequate switching arrangements, enabling the lighting in different sections of the room to be under control; a simple method of meeting the difficulty also is to instal plug circuits which can be connected to table standards at each desk.

If local lamps are habitually used, it is very important that each unit should be very well shaded, and, in order to avoid excessive contrasts, there must be a moderate general illumination (say of the order of 0·5 -1 foot-candle) over the rest of the room. During recent years there has been a progressive tendency towards general illumination from lamps mounted near the ceiling, well out of the range of vision. The development of the gas-filled lamp has favoured this method which is used in many large modern offices. It has the substantial advantage that by proper design the illumination can be rendered adequate for any rearrangement of desks and tables in the room; whereas, with local lights, though the lighting arrangements for each worker may possibly be more perfect, the system requires readjustment every time the room is rearranged.

The advantages of direct, indirect and semi-indirect lighting have been frequently discussed before the Society. Indirect lighting has the great advantage of completely screening the source from the eyes of the worker and thus eliminating glare. From the psychological standpoint it has frequently been described as "cold," and it is a question whether the depressing effect ascribed by some to the method has a real origin in the results of the system or is merely the result of unfamiliarity. In order to meet this objection the semi-indirect system, which permits of a visible source being seen, though of mild luminosity, has been introduced.

The method of merely placing a diffusing bowl round the light source has frequently been described as "semi-indirect" lighting. But in many cases this does not secure the inherent advantages of indirect lighting as regards distribution of light, and the writer, in common with others, has sought to meet this problem by adding to an indirect fitting a modification which produces the impression of "warmth" by allowing some visible source to be seen. Where the decorative effect is important recourse has been had to the use of a semi-translucent reflector, fitting closely inside a glass bowl lined with some coloured material, such as silk, in the manner shown in Fig. 1. Another method is to leave a hole in the bottom of a metal bowl, approximately one-third of its diameter, and insert some dense translucent substance such as opal glass or alabaster which transmits a soft glow. By inserting in the bowl the usual interior reflector, leaving only an aperture sufficiently large to cover the glass disc, practically all the available light can be directed on the ceiling. (See Fig. 2.)

As regards the choice of lamps, it is hardly necessary to say that, in modern office lighting, carbon filament lamps are scarcely ever used. Indirect arc lighting is still in use in certain cases (*e.g.*, drawing office lighting), but in general the choice, for electric lighting rests between vacuum tungsten filament and gas-filled lamps. The latter are likely to be very widely used where the overhead system of direct general lighting, or indirect and semi-indirect lighting, may be employed.

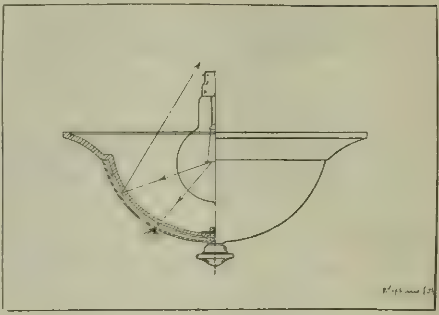


FIG 1.—Semi-indirect Lighting Unit.

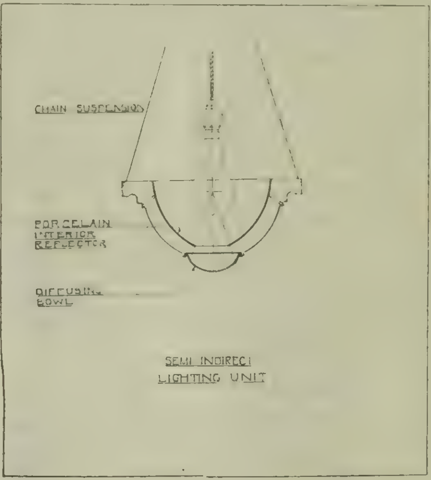


FIG. 2.—Showing small diffusing luminous area let into base of reflector.

A great deal of thought has been given to the spacing of lighting units with a view to producing uniform illumination. The usual procedure is to divide the room into squares, at the centre of each a unit is placed. The table, worked out in the United States, illustrated in

Fig. 3, may be put forward as an indication of the desirable sizes of squares to be adopted for different types of offices. Naturally this assumes that even lighting in all parts of the room is wanted, and even so it cannot be followed slavishly in all cases. The lighting engineer must consider each problem on its merits, and the theoretical spacing of units must often be modified by the positions of beams and pillars. For the sake of appearance the source must often be installed at the centre of the rectangle bounded by such pillars or beams. All such obstructions are apt to cast shadows which must be guarded against, and this furnishes a strong inducement to the use of light tinted walls and ceilings, which diffuse the light, wherever possible. Semi-indirect methods, which make good use of the ceiling-reflection, are particularly advantageous where such conditions are met. In industrial and commercial lighting the distance between adjacent units is commonly half the height, but this rule again is subject to variation according to the nature of the interior.

Kind of room	Ceiling height	Desirable length of side of square
Armories	12 to 16 ft.	12 to 16 ft.
Auditoriums	12 to 16 ft.	12 to 16 ft.
Public halls	Over 16 ft.	15 to 26 ft.
Rinks	Over 16 ft.	15 to 26 ft.
Stores	8 to 11 ft.	8 to 11 ft.
Stores	11 to 15 ft.	10 to 16 ft.
Stores	Over 15 ft.	14 to 22 ft.
Offices—with desk lights	10 to 20 ft.	12 to 18 ft.
Offices—without desk lights	9 to 12 ft.	7 to 11 ft.
Offices—without desk lights	12 to 16 ft.	9 to 14 ft.
Offices—without desk lights	Over 16 ft.	11 to 18 ft.

FIG. 3.—Desirable sizes of squares for use in lighting various interiors.

Type of reflector	Typical zonal distribution			
	0 to 60 deg., per cent.	0 to 90 deg., per cent.	0 to 180 deg., per cent.	Light absorbed, per cent
Prismatic—focusing	50	68	87	13
Prismatic—intensive	44	65	87	13
Prismatic—focusing (satin finish)	40	60	87	13
Aluminized steel—intensive	51	58	58	42
Aluminized steel—extensive	52	61	61	39
Prismatic—intensive (satin finish)	37	57	87	13
Medium density—opal	40	54	82	18
Prismatic—extensive	40	62	86	14
Heavy density—opal (depolished)	41	59	72	28
Light density—opal	34	57	91	9
Prismatic—extensive (satin finish)	33	55	88	12
Bare lamp (for comparison)	16	47	100	....

FIG. 4.—Distribution of light in various zones around tungsten lamps and inverted bowl reflectors. (SWEET, "The Choice of Reflector," Illum. Eng. Soc., New York Section, February 8th, 1912.)

The conditions shown in Fig. 4, which is taken from a paper read by Mr. Sweet before the Illuminating Engineering Society in the United States, are interesting as showing the distribution of light from typical inverted bowls and tungsten lamps in various zones.

Reflectors used for commercial lighting

may be of porcelain enamelled iron, stove enamelled metal, aluminised metal, mirrored glass, prismatic glass, opal or opalescent glass. Prismatic and diffusing glass are in general preferable for office use. It would take us too far afield to enter fully into the question of the relation of design of reflectors to efficiency.

Importance of Periodical Cleansing of Lamps and Lighting Units.

At this stage it may be well to draw attention to one important factor in office lighting, the frequent cleaning of lamps and reflectors. This applies specially to overhead systems of lighting, the cleaning of bowls and reflectors being apt to be overlooked, owing to their considerable height above the floor level. Accumulations of dust will often occasion a deterioration in illuminating efficiency to only 50 per cent., or even, in extreme cases, 75 per cent. of the initial value.

Offices are notoriously good harbourers of dust, the accumulation of files and masses of paper making constant cleanliness a difficult matter. Unpolished surfaces are specially apt to become coated with the dust thus accumulated and distributed. Fig. 5, which presents some data obtained in the National Lamp Works in the United States, gives a good idea of the effect of dust deposits on lighting units in reducing the available illumination. It will be noted that a dome enamelled steel reflector suffers less from dust than a light density opal glass; the latter type of lighting unit therefore requires frequent attention as dust deposits affect both the reflection and the transmission of light by the material.

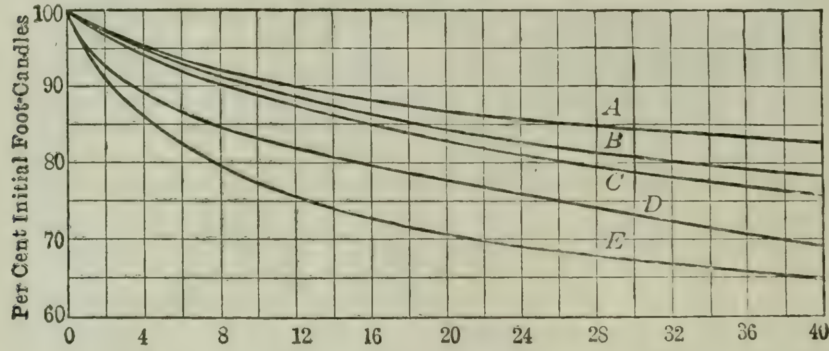


Fig. 5.—Reduction in light due to dust.

A. Dome enamelled steel.

B. Bowl enamelled steel.

C. Dense opal glass.

D. Prismatic glass.

E. Light density opal glass.

General Requirements in Office Lighting.

We may now proceed to state briefly some of the chief points that require attention in office lighting. First of all, however, a caution must be given against the impression that all offices can be lighted on a uniform plan, with lights of certain consumption or candlepower, at fixed intervals, irrespective of the kind of work that is carried out. Office lighting, it has been pointed out, includes many entirely different problems. A bank or an insurance office presents features quite different from those in a small city office; a room in which papers or forms are collected and examined at a single desk or table is again different in its lighting requirements from one containing rows of desks, at regular intervals, all devoted to the same class of work. Rooms devoted to storing and packing operations, commonly classed with offices, are again distinct from the cases mentioned above. Good results cannot be anticipated when large buildings containing many rooms given up to varied operations are wired on a rule of thumb plan. This has apparently been overlooked in some of the buildings hastily erected for office work in the course of the war. There are other cases in which hotels and other buildings, originally not intended for office work, have been taken over by Government Departments to house their staffs. Naturally the lighting conditions in a lounge or bedroom have proved unsuitable for office work, yet the existing wiring and position of lamps has often been adhered to with little or no adaptation to office needs.

We shall discuss shortly the requirements of a few distinctive types of offices. But it may be well first to summarise a few points which are, broadly speaking, applicable to offices in general. The points to be considered may be stated as follows :—

(1) *Illumination required on work.*—While in the past it has been common to assume 2—3 foot-candles as a minimum for reading purposes, experience shows that a considerably higher value is needed for most of the work in offices. Workers have to read not only printed matter, but typewritten documents, pencilled or ink-written invoices, forms, etc., and matter inscribed on more or less dark material. In the writer's experience 4—6 foot-candles is desirable for general lighting, while for desk-work, which calls for close attention and constant reading of written characters, a somewhat higher value, 6—8 foot-candles, is not unduly high.

(2) *Avoidance of Excessive Glare or Severe Contrast.*—While it is difficult to frame very strict rules for avoidance of glare (*e.g.*, by defining the brightness of surfaces of globes, reflectors, etc.), the rule embodied in the Report of the Home Office Departmental Committee on Lighting in Factories and Workshops should certainly be observed, *i.e.*, the worker should not be able to see any unshaded source when engaged on his work, nor when looking straight across the room horizontally. When general lighting is employed this condition can be readily complied with by placing sources high up, in appropriate reflectors or bowls, leaving a clear open space across the room. Semi-indirect lighting is one of the best modes of meeting the requirement. The question of prescribing a limiting brightness for the surfaces of bowls has been raised. It has been suggested that the latter should not exceed three times the brightness of the illuminated ceiling—a condition that could easily be met by the form of unit referred to earlier.

Semi-indirect lighting is also effectual in avoiding excessive contrasts in illumination. The latter are most likely to occur when reliance is placed on local lights, and there should be supplementary general illumination of, say, one-tenth of the working illumination at the desk, so that the eye is not fatigued by a sudden contrast in brightness when the gaze is transferred from the illuminated book or paper to the surroundings.

(3) *Avoidance of Glare due to Reflection from Polished Surfaces.*—Even when all precautions have been taken to avoid glare under heading (2) there is the danger of light being directly reflected into the eyes from polished surfaces. This is a common defect in offices and one difficult for the lighting expert to correct. The polished surfaces of desks, tables or wall-panelling, though often desired on decorative ground, are objectionable in this respect. It may be suggested that the Society should consider the recommendation of matt surfaces for furniture and walls in offices, as they have already done for schoolrooms.

(4) *Avoidance of Reflected Light from Paper, Ledger-surfaces, etc.*—Here, again, we have to deal with a factor not entirely within the control of the lighting expert. The constant reflection of light from glazed paper is probably one of the most usual causes of eye-strain in offices. It has also been pointed out to the writer that much inconvenience is caused by the direct reflection of light from some forms of writing, *e.g.*, characters written in pencil or more especially with copying ink pencils as commonly used in offices. Many forms, invoices, etc., written with such pencils on flimsy paper are extremely difficult to read, even with a very strong illumination, by reason of the fact that both writing and paper reflect light directly and there is insufficient contrast. It is doubtful whether this difficulty can

be overcome even with an otherwise sound system of general lighting. The writer invites suggestions on this point, but is disposed to recommend carefully adjusted local lights. Fig. 6 shows how, by selection of the angle at which light is received, such direct reflections can be largely avoided. But the best method of avoiding the troubles mentioned under this head is to abstain from using either highly glazed paper or writing materials, such as copying ink pencil, which leave a gloss.

(5) *Avoidance of Inconvenient Shadows.*—In many offices there are shelves, projecting racks, furniture, pillars, etc., which are apt to cause shadows. In some operations (drawing, for example, and typewriting) shadows are also apt to be caused by implements or the persons of workers. General illumination, especially semi-indirect lighting, making use of large illuminated surfaces, is the best method of guarding against this defect, and this is one reason why the author prefers semi-indirect lighting for general work. When local lights are used their position with respect to adjacent objects needs careful study.

(6) *Control of Lights.*—With a view to economy it is most important that lights should be under control, properly subdivided, with ample switching arrangements and provision of plugs for supplementary local lighting in special circumstances.

Different Types of Offices.

Unless there are special circumstances which favour local lights, the writer is disposed to recommend general overhead lighting, complying with the foregoing recommendations in most cases. In *Board Rooms, Waiting Rooms* and the offices of *Departmental Heads*, where visitors are received, decorative considerations play an important part and semi-indirect lighting answers requirements. The illumination may be of the order of 4—6 foot-candles.

In a fairly small office the positions of desks and tables are settled mainly by the positions of windows, and lights should be arranged with due regard to the work each operator has to perform. The rule that for reading and writing the light should come mainly over the left shoulder is sound. As an instance of the planning of lighting we may take the small office, 16 ft. square, shown in Fig. 7. Here the positions of desks are arranged with due consideration to the daylight, and if there are four people at work the desks can be situated round a common centre pendant as shown. If there are five people in the room the arrangement might be somewhat

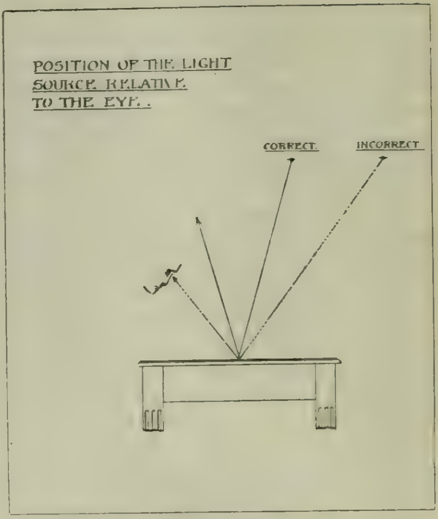


Fig. 6.

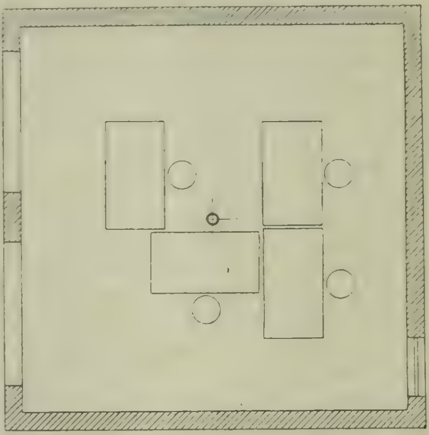


FIG. 7.—Office 16 ft. × 16 ft. (256 sq. feet) arranged for four people. One general lighting unit, consisting of semi-direct pendant with 150-watt gas filled lamp or semi-indirect pendant with 200-watt gas filled lamp, is installed in centre of room.

different, as shown in Fig. 8. In this case a central unit of fairly low intensity can be provided to give moderate general lighting, supplemented by lamps over each individual desk.

In small offices of this type it is well worth while to plan the positions of the desks and tables and fix the positions of lights accordingly. But when we have to deal with a room of large area, and many people working on identical operations side by side, a general semi-indirect system giving 4—6 foot-candles will do all that is needed. Diffusion of light is, however, an important point, since we rely on this for adequate illumination everywhere and absence of inconvenient shadows, irrespective of the positions of desks.

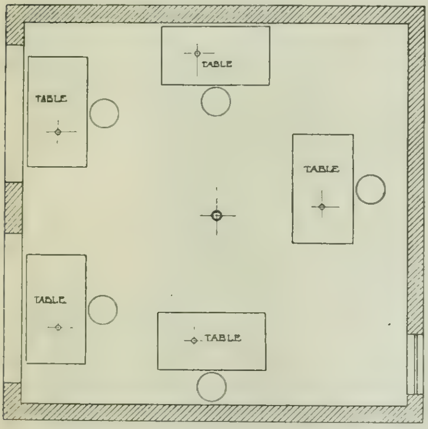


FIG. 8.—Office 16 ft. × 16 ft. (256 sq. feet), arranged for five people. Local points, each equipped with 40-watt lamp, half obscured bulb and intensive reflector, are mounted to serve the respective desks. A central semi-indirect pendant with 60-watt lamp, serves to provide supplementary general illumination.

One occasionally meets rooms where the important work is transacted almost entirely at one counter or desk. Here one would naturally provide a local light and a general moderate illumination, perhaps 2 foot-candles in the rest of the room. In other cases, however, goods and parcels have to be examined in all parts of the room, or forms examined and transferred from place to place. In such circumstances semi-indirect lighting for the whole room seems best, especially as, owing to the reflection of light from the ceiling, the angle at which any paper is viewed makes little difference to its appearance. The only drawback is the difficulty with glossy pencil writing referred to previously; this may call for a local shaded light to which papers can be taken which happen to be specially difficult to decipher.

Another class, *banks and insurance offices, etc.*, presents special features. Much of the work here is taxing to the eyes, and it was formerly the invariable practice to have local shaded lights at each desk. For the reasons indicated in Fig. 6 a sloping desk is an advantage in helping to eliminate direct reflection. For such work at least 6 foot-candles is desirable and the position and design of the local standards need careful study. Complete screening of the lamp from the eye, preferably by a shade with opal interior and green exterior, seems desirable. Lamps of smaller candle-power than 40-watt should not be used, owing to the difficulty in obtaining a reasonably uniform illumination over inclined desk-surfaces. The lower half or one-third of the lamp should be frosted. This is a precaution against glare, but also important in reducing streakiness and tendency to direct reflection of an inconvenient kind. Local lamps arranged over desks and counters at banks have to comply with various special requirements, not always appreciated. For example, their height above the counter may appear unduly great, increasing the depth of shade necessary to screen the lamp and increasing the difficulty of lighting the whole area. But this height is often necessitated by the fact that bulky ledgers must be handled; even so lamps are apt to be broken by shock.

It is a matter for consideration where adequate general illumination can entirely displace such local fittings. At present they are widely used and the Society might consider the question of specifying exactly what the qualifications of a good stand lamp should be, including height and candlepower of lamp, position with respect to work, nature of shade, etc. Many people consider that such local lighting aids mental concentration, and the decorative and ornate style of some banks and insurance offices makes it difficult to apply semi-indirect lighting. On the other hand, where suitable reflecting surfaces exist this method of lighting lends itself well to the requisite decorative treatment, and provided the illumination is uniformly high (say 5—7 foot-candles) there seems no reason why, in such cases, it should not displace local lamps. In any case, even if local lights are used, some supplementary general illumination (say up to 2 foot-candles) is necessary both to relieve contrast and to diminish the shadows to which local lighting is apt to give rise. A number of illustrations of typical office lighting, including general offices, banks, insurance offices, etc., are given in Figs. 9—14.

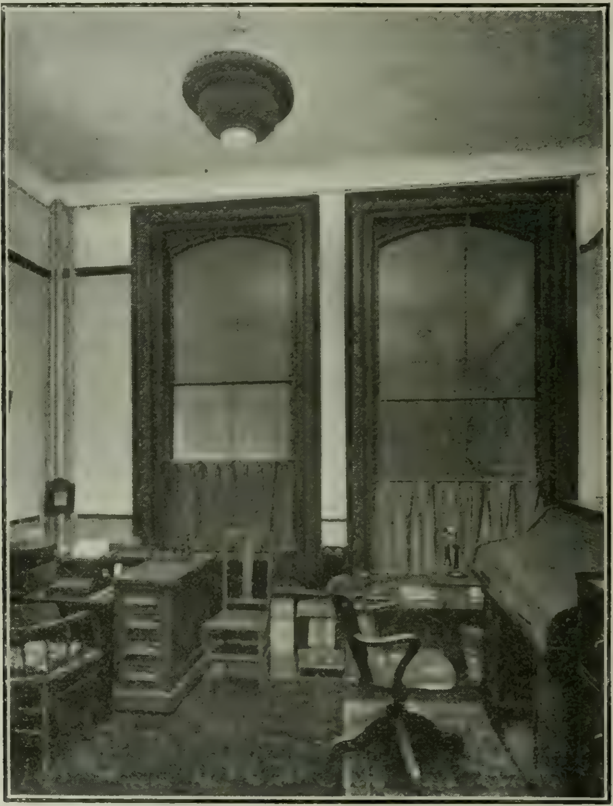


Fig. 9.—Private Office. Semi-indirect Lighting.

There remain a few special problems in office lighting to which reference may be made.

The lighting of large vertical surfaces, notice boards, shelves, etc., is known to be a somewhat difficult problem, which was referred to in the discussion on Library Lighting before this Society in 1911. Special reflectors have been devised to spread the light uniformly over such areas, but, if the light is obtained from a single source, the oblique angle at which it reaches the more remote regions of the surface is sometimes a difficulty. In general the high vertical illumination and the uniformity of effect obtained from general semi-indirect illumination is sufficient for the lighting of any shelves in the office and this has

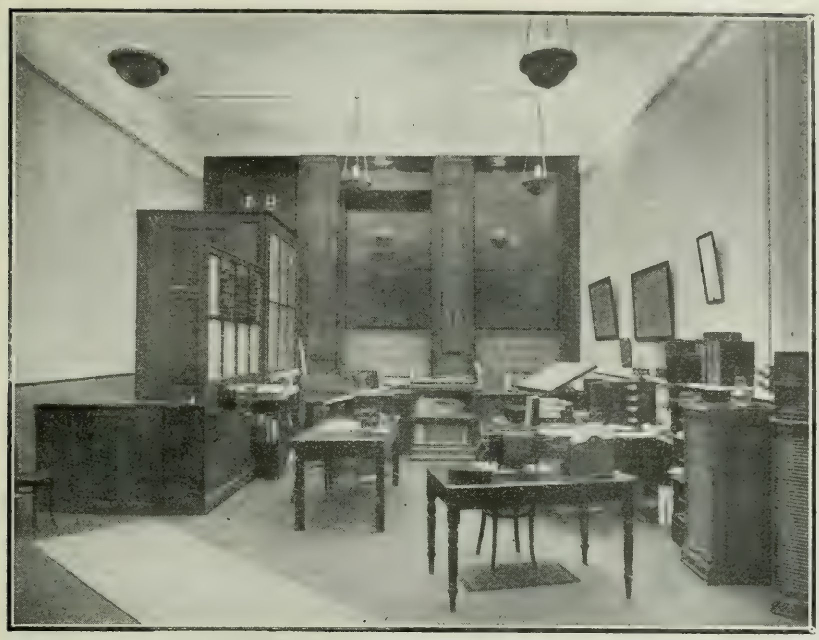


FIG. 10.—General Office. Indirect Lighting.

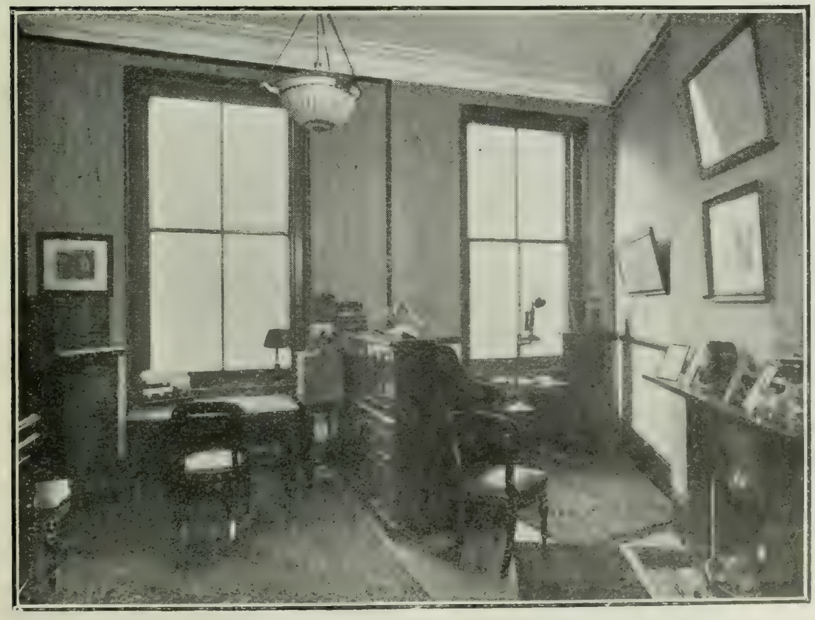


FIG. 11.—Private Office. Semi-indirect combined with Local Lighting.

also the advantage that inconvenient shadow from the body of the person inspecting the shelf or other surface is largely avoided. For the same reason semi-indirect lighting is an effective means of lighting pigeon-holes and drawers as the light derived from the large illuminated ceiling area penetrates into the corners and recesses and little shadow is cast.

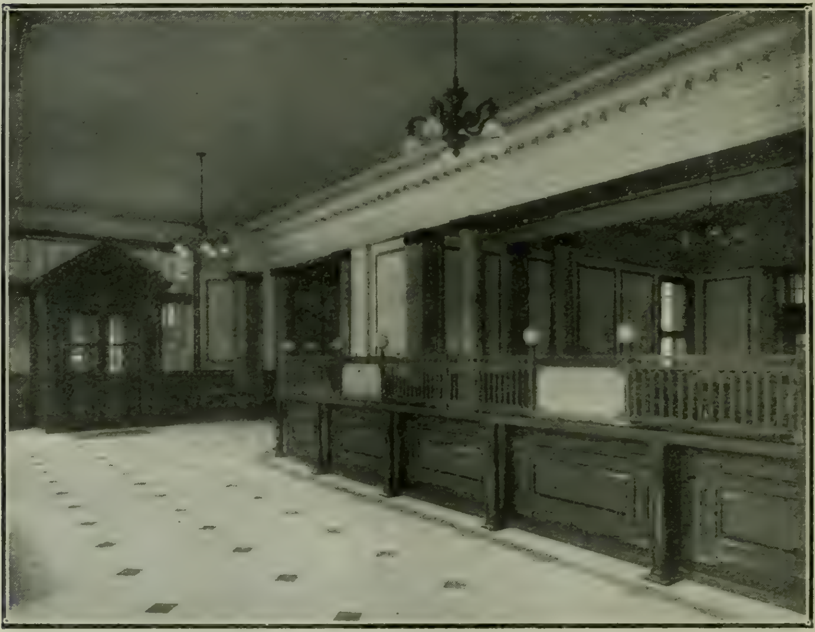


FIG. 12.—Insurance Office. Direct "General" Lighting with local units.

Another special case in lighting is afforded by typewriters. Here we have a reversal of the established rule that light should be directed from the left-hand side. The notes of typists are usually placed on the left-hand side of the machine and light must be thrown on these, but also upon the front and keyboard. The best arrangement, where local lighting is provided, is an oblique reflector placed at an angle of 45 degrees with the machine, in the manner indicated in Fig. 15. Care must be taken that the light is shielded from the operator's eyes.

The Lighting of Drawing Offices.

The lighting of drawing offices is in a class by itself and has been the subject of much difference of opinion amongst engineers.

Two systems are at present in use: (1) Local lighting from individual points installed over each drawing board, and (2) General indirect lighting. Direct lighting has the advantage in dealing with dense tracings, where one has a peculiar double surface to deal with, namely, a more or less shiny cloth above and the drawing paper below. The position of the unit requires great care as it must not shine in the observer's eyes and must not be so placed as to cause inconvenient shadows from the instruments or from the worker's person. The remarks on the importance of avoiding glare applies also to sources used for neighbouring boards. The reflector used should be opaque, preferably of aluminium vitreous enamel lined steel or porcelain.

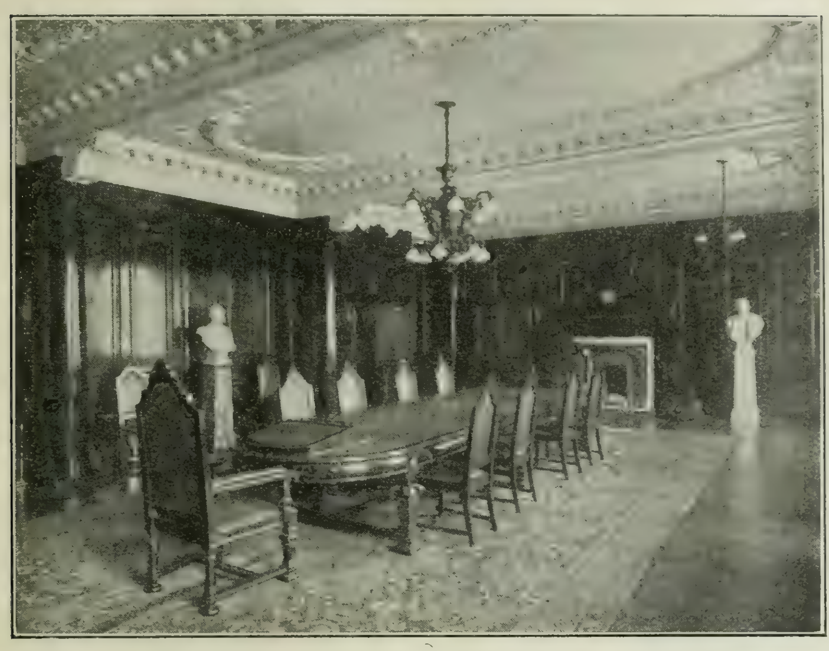


FIG. 13.—Board Room. Direct " General " Lighting.

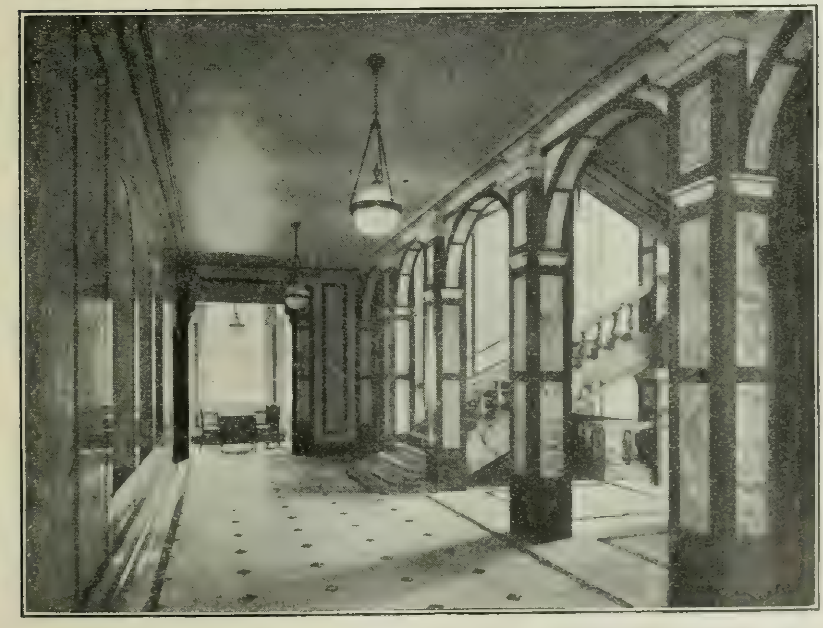


FIG. 14.—Insurance Office Staircase. Semi-indirect Lighting.

Half-frosted 60-watt lamps are recommended, and an intensity of illumination of at least 8 foot-candles should be available.

Fig. 16 illustrates an efficient device that has been used with success is a standard consisting of a telescopic pedestal and arm, which enables the lamp to be adjusted to any desired height and placed in the most convenient position over the board.

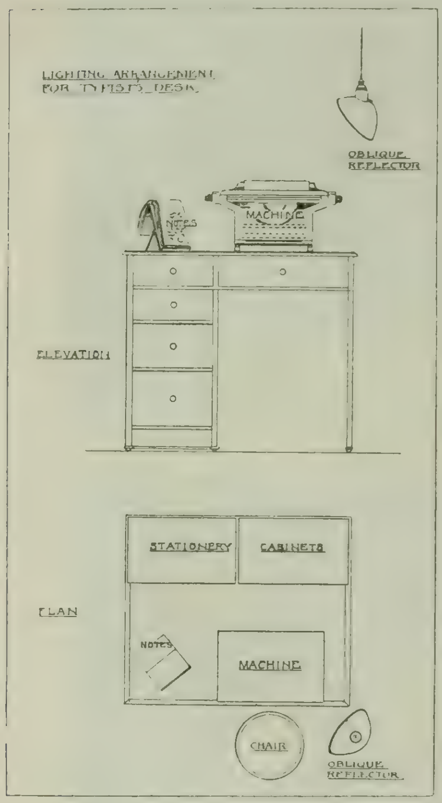


FIG. 15.

In view of the importance of avoiding glare and inconvenient shadows there is much to be said for indirect lighting. The sources can then be arranged irrespective of the positions of the drawing boards. A most important consideration is cleanliness of ceiling, which should be white, while walls should, if possible, be distempered a matt light blue or light green. Any polished objects such as pictures with glass in front should be removed. For general work, and when the artificial lighting is used during the greater part of the draughtsman's work, indirect lighting may be recommended, although in certain varieties of fine work, and especially in tracing drawings with fine lines, local direct lighting may be a convenience.

With indirect lighting an illumination of 12 foot-candles is recommended.

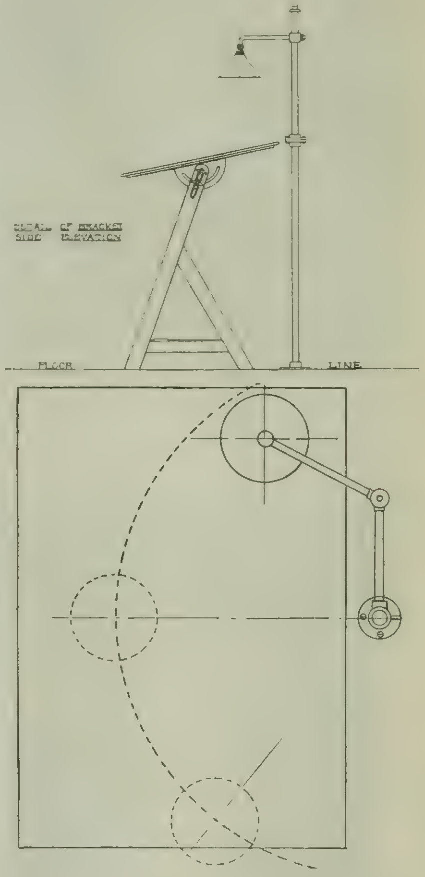


FIG. 16.—Drawing Table. Lighted by Local Illumination.

Daylight from windows should be incident from the left side of the board. Where top lights exist these form a useful adjunct, but direct sunlight should not be allowed to enter a drawing office; light blinds should be provided which serve to cut off the direct rays of the sun without unduly darkening the room.

The lighting of drawing offices is one problem that deserves fuller discussion, and it is hoped that the paper will be useful in eliciting views on this subject.

It is also to be hoped that some of the suggestions made will lead to the framing of some definite recommendations by the Society on the subject of office lighting. In all office work the provision of suitable natural and artificial light is of great importance. The eye is one of the most susceptible organs of the body and when it is recalled that in office work it is subjected to more or less strain for considerable intervals of time one can appreciate how greatly this strain can be relieved by suitable illumination or accentuated by bad conditions.

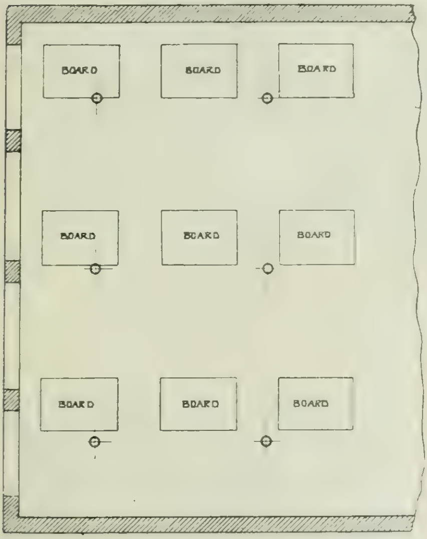


FIG. 17.—Drawing Office. Lighted by Indirect System.

In conclusion the author wishes to thank the Pearl Assurance Company and the Société Générale (de Paris) for their courtesy in permitting photographs of their offices to be taken and reproduced.

SUPPLEMENT

A New Form of Focus Type Metal Filament Lamp.

OSRAM CONE FILAMENT FOCUS LAMP.

It may interest the Members of the Illuminating Engineering Society to know that the illuminant used in the lantern this evening is a new form of tungsten filament lamp.

It has been developed by the Osram-Robertson Lamp Works, and consists of a conical spiral filament operating in an atmosphere of nitrogen. The efficiency at which the lamp is run is 0·6 watts per candle, measured in the axis of the cones. The advantage of this form of filament is that it presents practically a solid disc of light, and when accurately focussed throws no shadows on the screen. It eliminates the necessity of an accurately focussed mirror such as is advocated in the wave or grid form of projection lamp.

Unfortunately its manufacture is limited to a maximum of 20 volts at present, which, therefore, restricts its efficient use to A.C. circuits or secondary batteries.

For research laboratories, however, it should be an ideal illuminant for projection work, owing to the constancy of the light and other properties possessed by tungsten filament lamps.

DISCUSSION.

Mr. F. W. WILLCOX said that the Society was to be thanked for taking up the important question of office lighting. A notable characteristic of office illumination in Great Britain was the very low prevailing standard which in London was much lower than that prevailing in many other large cities in the United States and Continental countries. In view of the climatic conditions of Great Britain this was rather surprising, as one would expect interior illumination would be all the brighter by reason of the dull days and general lack of sunlight, particularly during the winter season. The low degree of illumination was no doubt a relic of the old "drop-light" era which originated with the inefficient carbon incandescent lamps used with the old conic opal shades.

A feature of modern illumination, as Mr. Wise had noted in his paper, was the tendency towards "general illumination," with lamps placed well above the line of vision, and equipped with suitable diffusing and distributing equipment to properly light the whole of the interior, in place of local illumination, with the old drop-lights merely placed here and there over desks.

The advent of the half-watt or gas-filled type of electric lamp had made general lighting not only economically possible, but in a large sense necessary. Such lamps were of intense brilliancy and could not be satisfactorily used directly or in a local way as the old lamps were. It was necessary to employ such brilliant filaments in such a way that no direct rays could reach the eye, and this condition, therefore, required general illumination.

In "general illumination" methods, desirable practice tended to indirect and semi-indirect methods rather than the direct method of lighting, for the reason that at the usual heights of ceilings found in offices the brilliancy of the modern half-watt lamp was too much in evidence when the lamps were used directly, even though they might be placed well up on or close to the ceiling. Modern office lighting, therefore, could be typified as the "bowl lighting" era, *i.e.*, the lamps were used in some form of bowl or dish, ranging from an ordinary opal glass bowl through varying degrees of density to pure alabaster and on to the absolutely opaque bowl containing suitable reflectors by which the light is all thrown to the ceiling and diffused about the room from the ceiling as a secondary source.

Mr. Wise's paper indicated a distinct preference for semi-indirect lighting, but he did not seem to have considered fully the comparative moods of indirect as well as semi-indirect lighting. He (Mr. Willcox) could not agree to the suggestion that indirect lighting is cold. It was possible to design almost any system of lighting so that it would appear cold, but properly designed indirect lighting, however, had a degree of warmth and agreeableness and comfortable effect which was not obtainable by any other system of lighting. It was natural that the average person, without previous knowledge of the subject, should choose a semi-indirect bowl in preference to a total indirect fitting because of the psychological desire of the average individual to have the place where the light originated discernable; but this idea soon vanished with experience of indirect lighting. Indirect lighting was probably the most fool-proof of any form of lighting against glare and disagreeable and un-uniform lighting effects, and properly installed, conformed closely to the unconscious effect of daylight.

No doubt it was difficult for Mr. Wise in the compass of one paper to have discussed too many phases of this wide and very interesting subject, but he (Mr. Willcox) would have liked to have seen included certain points, such as the energy consumption required per square foot for different systems of lighting and intensities. Mention might also be made of corridor lighting in office buildings, which was too often executed in a niggardly and unsatisfactory manner. Instead of being repelling and gloomy, as was often the case, corridors should be attractively lighted so as to give a sense of welcome when one entered the building, and should thus form a good advertisement for the building and all its tenants. Modern systems of general lighting contributed greatly to the good spirits and general health of employees and the avoidance of eyesight and nervous troubles, which were aggravated by the use of local drop-lights in an otherwise dark room.

Mr. Wise alluded in the first part of his paper to a consumption of 50-watts per person as being an extravagant figure. Surely, as this was the figure used in the old drop-light era when each employee had a single carbon lamp hanging over his desk, it was not extravagant to spend at least this amount for general lighting.

It should be pointed out that the glassware of a semi-indirect unit should be quite dense, *i.e.*, it must transmit only a small part of the light directly to secure the desirable lighting conditions. If glass bowls of light density were used the bowls were apt to become a very bright source of light, and the system

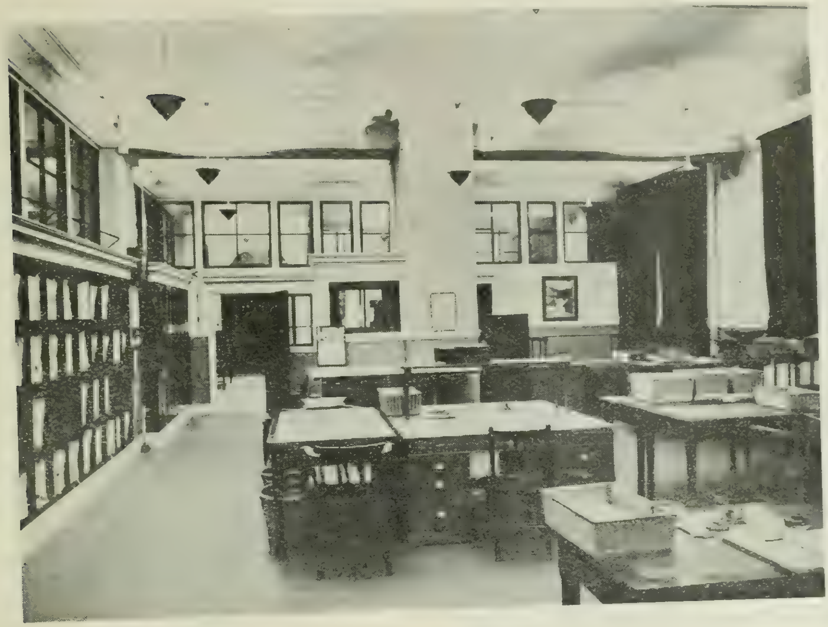


FIG. 1.—Office Lighting (night view). Indirect Lighting Offices Crown Agents for the Colonies, Westminster.

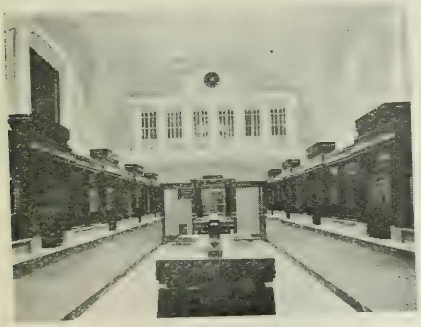


FIG. 2.—Indirect Lighting (night view), with equipment located in top of counter railing structure. Gives a clear overhead with no fittings visible.

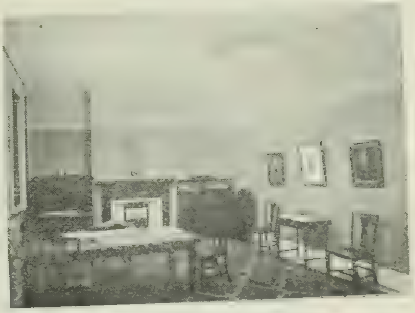


FIG. 3.—Indirect Lighting (night view), with luminous panel bowls. Armstrong-Whitworth's Offices, Newcastle.

was thus converted very largely into the direct lighting class, with all the objections of bright objects in the line of view. There was a wide difference between semi-indirect fittings in this regard.

Also too much attention could not be paid to the proper height and suspension of semi-indirect fittings and the proper location of lamp in the bowl, so to distribute the light upon the ceiling as to evenly illuminate the ceiling and the room. In many cases semi-indirect fittings were hung too close to the ceiling, with the result of concentrating the light on a narrow circle of the ceiling just over the fitting, giving very unsatisfactory illumination. Illuminating engineering advice and direction was needed for the proper installation and use of such fittings. Mr. Wise properly emphasised the importance of avoiding glare, and severe contrast, and reflection from polished surfaces, such as surfaces of paper, books, etc. He also referred to the objectionable effects of inconvenient shadows. All such difficulties were most effectively avoided by wholly indirect lighting, of which some examples are given in the photographs herewith (Figs. 1, 2, 4, and 5). Indirect lighting more surely corrected the evils of glare and reflection than semi-indirect lighting could possibly do by reason of the absence of any direct lighting.

Mr. Wise had not referred to the system of lighting (now becoming more general) in which the structures in the room are used to support indirect lighting equipment. Thus in banks the tops of counter rails, and in libraries the tops of book-shelves, and similar structures in other offices, could be employed to locate and conceal indirect lighting equipment and render unnecessary the use of any exposed fittings. Very beautiful and effective lighting results are obtained in this way with perfectly clear overhead space free from fittings, as shown in Fig. 2.

Drawing office lighting alone could occupy a whole evening's discussion. Very effective results had been obtained with general illumination by both semi-indirect and indirect systems. An excellent example of indirect lighting in a drawing office was shown in Fig. 5. The semi-indirect lighting with large units was employed in cases where there was a skylight or no ceiling to accommodate indirect lighting. A good example of this form of lighting is given in Fig. 6. Fig. 4 showed a draughting room lighted by indirect lighting with trough reflectors fitted to the edges of the cross girders. In tracing work general lighting was quite frequently aided by the use of a local lamp placed beneath plate glass drawing boards. This ensured easy, clear, and accurate tracing.

He could not agree with Mr. Wise in some of his classifications. Thus Fig. 14, showing an insurance office staircase lighted by an opal glass sphere, could not be properly called "semi-indirect lighting." Such a system, *i.e.*, lamp placed inside of an opal glass ball or sphere, was more properly termed a "diffusing" system, because such balls or spheres diffuse the light and did not in any real sense direct it. Similarly, Mr. Wise had applied the term "indirect lighting" to an indirect fitting having a luminous panel, as illustrated in his Fig. 10. This type of fitting had been developed some years ago in the United States, and numbers of such installations have been made on this system throughout Great Britain. A good example of such a system is shown in Fig. 3, which shows the lighting of one of Armstrong Whitworth's private offices, Newcastle. Such a system has always been described, and properly so, as an indirect lighting equipment with luminous panels. These panels could be made luminous either by letting the light of the main lamps come through or by including a group of small lamps to light the panel, leaving the indirect lighting to the main lamps and reflecting equipment. The use of the term "semi-direct" in addition to "semi-indirect" for the same system of lighting (opalescent bowl or hemisphere) would also result in confusion with no compensating advantage.

This classification of systems of lighting was extremely important to the Illuminating Engineering Society, and it was very desirable that some recognised classification should be promulgated to avoid confusion.

He ventured to put forward, therefore, the following recommendations for the consideration of the Society as classified systems of lighting :—

(A) The *Direct Lighting System*, which conveys the light direct to the surfaces to be illuminated. (Examples : Prismatic glass reflectors, vitreous enamel steel reflectors.)

(B) The *Indirect Lighting System*, which reflects all the light towards the ceiling or an upper surface, from which it is again reflected and diffused about the room.

(C) The *Semi-Indirect Lighting System*, which is a combination of the direct and indirect lighting systems. It employs a glass dish or hemisphere which makes a division of the light between the upper and lower hemispheres, giving a direct component of light downwards and an indirect component of light reflected from the ceiling or an over-reflector. (Examples: Alabaster or alabaster glass dishes.)

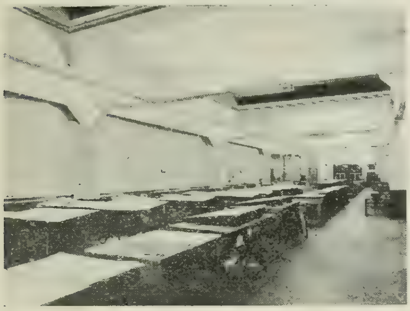


FIG. 4.—Drawing Office Lighting (night view). Indirect Light by "Mirolux" Trough Reflectors attached to cross girders.

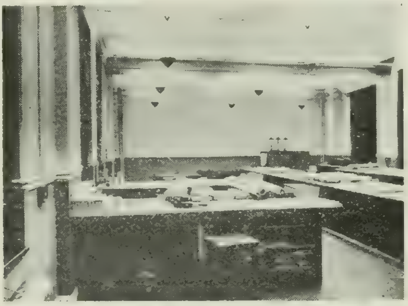


FIG. 5.—Drawing Office Lighting (night view). Indirect Lighting.

(D) The *Diffusing System*, which employs a sphere or opal globe completely enclosing the lamp. The light is diffused or distributed by the enclosing glass globe. (Examples: Alabaster glass spheres and balls.)

The above four systems covered practically all methods of lighting except the artificial skylight or panel lighting from luminous panels placed in the ceilings of rooms.

With regard to the lighting of typewriters, the method illustrated by Mr. Wise was open to several objections. A reflector suspended as shown in his Fig. 15 by a drop cord could not be held in the fixed position necessary to throw the light upon the work, but was liable to twist about, causing confusion and glare. Furthermore, in a room containing many typewriters, equipped with

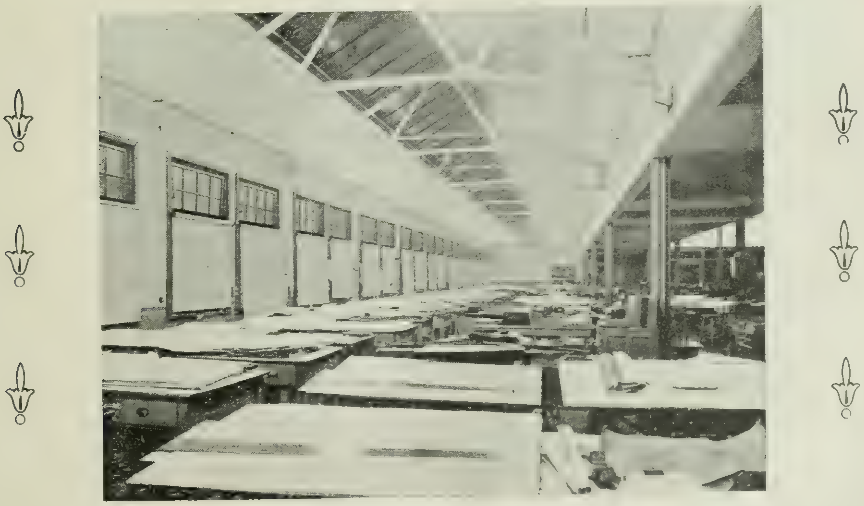


FIG. 6.—Drawing Office Lighting.
These Semi-indirect fittings have an over reflector (forming a semi-enclosed unit) for use under the skylight roof.

such angle pendants, it would be found that glare would be unavoidable through the lamps being visible to any operator looking across the room.

Very full and complete data had been given on the subject of diffusing glassware for semi-indirect fittings and the varying indirect components from various types of glass in a paper by Rowe and Magdsic entitled "Photometric Analysis of diffusing glassware with varying Indirect Components" (*Trans. Illum. Eng. Soc.*, U.S.A., 1914). This paper dealt particularly with glass diffusing bowls as employed in semi-indirect lighting. Further data as to comparative results obtained by direct, semi-indirect and indirect methods of lighting offices were to be found in a paper before the same Society by E. J. Edwards and Ward Harrison entitled "Some Engineering Features of Office Building Lighting" (*Trans. Illum. Eng. Soc.*, 1914). Another interesting question was the wiring of fixtures from the standpoint of upkeep and costs of service—the rental value of office as effected by natural and artificial illumination, and the value of artificial lighting as compared to daylight. These topics were quite fully discussed in a paper by S. G. Hibben, entitled "A Study of Economic Office Building Lighting" (*Trans. Illum. Eng. Soc.*, 1916).

In conclusion, he wished again to emphasise the waste and inefficiency in office work due to niggardliness in the use of light. The total cost of good lighting for an office did not exceed 2 per cent. or 3 per cent. of the wages, and the difference, therefore, between good light and poor light was generally less than 1 per cent. of the wages. 1 per cent. of an office day amounted to about five minutes, and there could be no question, therefore, that the better volume and quality of work possible with good lighting saved not five minutes per day but many times this number of minutes. As Mr. E. L. Elliott has well said: "Of all economies the wisest and most satisfactory is that which avoids the waste of human energy, whether physical, intellectual or moral. To wantonly waste human effort is a conscious sin, which in human law constitutes crime. To knowingly require man to labour under conditions which require a greater amount of energy than necessary is a transgression of the moral law as well as of economics. Poor or insufficient light is indefensible from every standpoint. By preventing human effort from achieving its full results it wastes human life, and by reducing the material results of human labour it impoverishes not only the labourer but all those who must purchase his products, which it necessarily increases in price. The cry for economy was heard in the land. But let us begin with the most vital of all economies, the saving of human energy, and to this end let us not overlook the fact that we work by sight; that we see by light. Let us have more and better light."

Mr. R. **Claude Bussell** remarked that the lecturer had omitted all reference to gas or other alternative illuminant. It should not be inferred that the lighting of offices could only be successfully accomplished by means of electricity. All offices could not be confined to urban centres where electricity was available, and those using a temporary office, or premises situated in the country or one of the proposed village centres, often had to employ other methods of lighting. He regarded as doubtful assets matt surfaces for walls and particularly for furniture, since from their very nature matt surfaces were peculiarly prone to collect grime which was virtually irremovable—a shortcoming going far to nullify any advantage that might accrue from the elimination of gloss.

Mr. J. H. **Jones** expressed the view that in many offices the amount of illumination provided was still too low, and he thought that the working illumination should not fall below the value specified in the author's paper. He thought that there was much to be said for cornice lighting in large public offices if judiciously supplemented by local units. The method had distinct advantages as regards elimination of shadow, while from the æsthetic standpoint it conveyed the impression of space and could be aptly incorporated in the design of the architect for large interiors. It was, however, essential that the design of such methods should be worked out at an early stage in the equipment of the building; this, and other lighting problems, involved close co-operation between the architect and the illuminating engineer, and in many cases the lack of such co-operation was responsible for a great deal of faulty lighting practice.

Mr. F. S. DENNISON said that it was most important that the reflecting surfaces of shades used for lighting should be free from dust. Illuminating engineers frequently laid stress on this point, but it was difficult to get the instructions carried out. Users required education in this matter. He noticed that some difficulty appeared to exist in framing definite regulations for the avoidance of glare and excessive contrasts. In this connection he would like to refer to the code on office lighting framed in the United States, which had been mentioned in THE ILLUMINATING ENGINEER. It was most important that consumers should recognise that all illuminating schemes require special treatment, and a long-felt want was recognition of "Efficient Lighting Standards" designed for the purpose of meeting the requirements of practically all the various kinds of work carried out.

Mr. A. CUNNINGTON said that he was called upon not only to equip but to maintain lighting installations, and frequently had to make alterations required by changed conditions of work and new positions of furniture. During the past four years, in order to deal with war-time staff in the offices with which he was concerned, desks had been moved about from place to place and new tables pushed into odd corners. To deal with such conditions with drop lights was bound to be unsatisfactory and necessitated flexible leads in all directions. He had experienced so much trouble in this way that he had been converted to general lighting on the semi-indirect system for such offices, so as to make the lighting independent of the positions of desks and tables. There seemed no reason why this system should not be widely used with gas lighting, where it had distinct advantages in view of the somewhat higher candlepower units in general use. Probably semi-indirect lighting with gas would be more widely employed in the future.

He thought Mr. Wise was too generous when he suggested 6—8 foot-candles as preferable to 3—4 foot-candles. From the standpoint of expense it made a great difference which of these two values was adopted. He quite agreed that a degree of illumination adequate for the work should be provided, but if four foot-candles sufficed, why provide eight? Mr. Wise had regarded 50 watts per person as an extravagant figure, yet the examples he had given would apparently work out at this figure. In an office where there were 200 clerks this would mean an annual lighting bill of, say, £500. He thought that 30 watts per person would in general suffice; if so, there would be a saving of £200, which directors would not be likely to ignore. It was the business of the illuminating engineer to provide just the illumination needed, neither too much nor too little. He agreed that in the past the tendency had been to be content with somewhat meagre illumination, but it seemed rather in the other direction now.

There appeared to be some uncertainty in the paper as to what constituted an undesirable contrast. In one part the author suggested 1/10th of a foot-candle, as supplementary to the local working illumination; but in another place he referred to an additional 2 foot-candles. A suitable figure would probably lie somewhere between the two values.

Referring to the lighting of a typewriter, he was not sure that the light should be to the right of a typist, because if she leaned forward a little a shadow of the head would be cast on the notes. The reflected light from shiny paper was a great difficulty, and if the material was both highly coloured and glazed it was often hard to read pencilled matter. High illumination, however, did not afford a complete solution of the problem and might even accentuate the difficulty. Nor did the method of placing the lamp recommended by the author seem a perfect solution. Possibly it would be an improvement to put the light behind so that the rays came over the left shoulder. The design of standard table lamps had been rightly described by the author as an important matter, but he was afraid that the Society would find it difficult to frame definite recommendations which would allow for the great variations in personal taste. Adjustable brackets were useful for lighting small sets of pigeon-holes where the general lighting was inadequate. He recalled one fitting, consisting of a small lamp in a reflector at the end of a jointed arm, which could be moved up and down a 10 ft. length of shelves, and had proved satisfactory. He had also tried a sliding light for long stacks of shelves which did not warrant elaborate general illumination, with fairly satisfactory results. When the shelf area was very extensive the problem could be met by using a portable lamp.

Mr. G. P. GARBETT said that in putting up bowl-fittings he had placed prismatic reflectors on the top of the bowl, which apparently gave rise to a better illumination underneath the bowl. It might be considered that by so doing the object of securing diffusion of light from the ceiling was defeated, but the method had the advantage that the trouble due to dust collecting inside the bowl was very largely avoided. He agreed that the cleaning of lighting units at frequent intervals was very desirable, but in the case of some varieties, utilising small prisms, the maintaining of a clean surface free from wedged particles of dust presented great difficulties.

Mr. O. L. BOYSE said that he spoke as a consumer anxious to obtain the best results in office lighting. He represented a large house in the City ; his building was on nine floors, and he thought that at one time and another they had tried almost every variety of lighting fixture with varying degrees of success. He thought basin lights placed flush to the ceiling unsatisfactory. They were too much out of the way for cleaning purposes and the light given was very dim. Trough lights over the clerks' desks were also unsuitable, as it was found that the lamps were often being broken by impact with books. Another difficulty was that the books on the desks were not evenly illuminated—the lower part of the books being hardly lighted at all. He was of the opinion that standard lights on typists' desks were a great mistake. These were often getting broken, and the typists found the light very trying owing to jerkiness caused by the typewriter.

One of the most objectionable lighting arrangements, he thought, was the indiscriminate use of reflectors at different angles. One sometimes entered an office and found oneself immediately surrounded by glares from all directions, which made it a matter of difficulty to single out the man you wanted.

For shelf lighting some reliable form of flexible torch was required. Hand torches connected to a length of flexible wire gave constant trouble owing to interruptions of the electric circuit and short circuits, and there was always the danger of entangling oneself in the wire, with the result that the wire was pulled away from its connection.

Well-designed local lights were certainly best for ordinary reading and writing purposes. He considered these were open to objection if one wished to refer to, say, the drawers of a desk or files in another part of the room. For general lighting he was of the opinion that the light should come from the ceiling, but that it should be evenly distributed. Would it not be possible to have a translucent ceiling with lamps evenly distributed above it so as to diffuse an even light without shadows throughout the entire room ? He quite agreed that any installation of office lighting should be studied scientifically and not adopted in a haphazard fashion.

Mr. A. WISE said that this system was in use in the House of Commons.

Mr. P. J. WALDRAM drew attention to the objectionable direct reflection from polished metal attachments to fittings, especially if seen against a dark background. He mentioned a case of a workshop in which the spindles for small parts for aeroplanes were being turned, and a bright line of light was reflected from the spindles. This caused eye-strain, but the trouble was eliminated in a simple manner by spreading pieces of white paper over the tables, which relieved the contrast. The effect from polished fittings adjacent to lights in offices was very painful.

In drawing offices he had found that a good effect was secured by using the lamp inside a box with a piece of ground glass let into the top. In mechanical drawing offices a draughtsman had often to draw from the actual mechanism, which required very careful lighting, so as to avoid direct reflections. When scribing on a piece of metal good results could be secured by placing the metal on a sheet of ground glass.

Mr. J. S. Dow said that the paper illustrated how dependent the efforts of the illuminating engineer were upon extraneous factors such as light ceilings, absence of polished panels of dark wood, and other inconvenient reflecting surfaces; while, as several speakers had remarked, it was difficult, if not impossible, to provide a satisfactory reading illumination when matter was written in copying ink pencil on flimsy shiny paper. The discussion had dealt mainly with the lighting of actual offices, but he would like to include such accessories as lifts and staircases. It was a most dangerous practice for the habit to develop of working a lift without ample light in it; he had met cases where an open space existed, no light was provided, and one could not tell whether the lift were in position or no. Similarly, when a stairway served a group of offices, it should never be left unlighted so that late workers had to stumble down in the dark.

In general it was much better to aim at good general, well-diffused lighting than to try to adjust the lights to suit individual typewriters, shelves or desks. One objection to direct lighting for shelves was that head shadows were apt to give trouble. This could be almost entirely avoided with good semi-indirect lighting. An exception to the foregoing remark was to be found in drawing offices. He agreed that for fine work a local light was necessary. Indirect lighting had apparent advantages as regards absence of inconvenient shadow. It must, however, be remembered that when one's head was bent over the drawing board the actual illumination was much reduced, even though the edges of the shadow might be so soft that one could not see it: one only appreciated the extent of this diminution when one made actual photometric measurements. Unless the general illumination was very high there was a danger that the value might be diminished to an undesirably low value when operators bent over their work.

He was much interested in the special projection lamp Mr. Wise had shown. It was a most difficult matter to secure even screen-illumination from an electric incandescent lamp. It was generally assumed that, to avoid this streakiness, all parts of the filament should be in the same plane. In the lamp shown by Mr. Wise this was not the case, but apparently this did not matter because there were no apparent gaps between the individual coils of the filament. The lamp would no doubt prove useful for small portable lanterns and for special optical apparatus such as mirror galvanometers.

The President said that they had had a most interesting discussion, in which the knowledge of those engaged in equipping installations had been supplemented by the experiences of those who had to use them. A bad feature in many offices, which reflected on the design of the fixtures used, was the makeshift devices often used, such as tying strips of blotting papers to the shades. These devices usually indicated imperfections in the shades used, and it should be the business of the Society to ensure that suitable modern lighting appliances were substituted. In his personal experience he liked to have plenty of light on the table and the rest of the room in comparative darkness, though he was aware that different views were held by others. He still thought there were advantages in this method of lighting, because it was restful to the eyes.

A drawing office was a most difficult problem in lighting, and much latitude must be allowed to the preferences of individual draughtsmen. For this reason adjustable local lights were necessary, though there should also be a considerable general illumination in the room. Another reason why he preferred local lights was that they enabled one to follow the point of one's instrument owing to the small shadow caused; if there was no shadow it was not so easy to do so unless the general lighting was profuse. An objection to standards was that they got in the way of rolls of paper, bulky drawings, etc., and it was therefore better to suspend the light from the ceiling. There was, however, room for the invention of a really satisfactory movable light so that the clumsy makeshift devices so often seen in drawing offices might be avoided.

Mr. J. DARCH (*communicated*): Broadly speaking, it is sufficient to consider office lighting as of two kinds, general and local, beyond which the endless diversity of special problems which one finds, and which a knowledge of the principles of illumination should always be able to satisfactorily solve, are too variable to be assigned to any class.

General lighting will, in most cases, best meet the needs of the large office or where there is much movement and traffic—assuming, of course, that the work is ordinary writing or ledger work. This may take the form of direct ceiling lighting if it is possible for the lights to be kept above the eyebrow angle; but I should, as a rule, prefer indirect lighting as it is so much better diffused and minimises the irritating gloss from desks and walls. There should be an illumination of at least 3 or 4 foot-candles on the desks.

Local lighting, in the majority of cases, is best suited to the smaller or quieter offices or where the nature of the business calls for it, and preferably, though not always, with the addition of general lighting, placed well out of the line of sight, of 1 foot-candle, more or less. The lamps should not be fixed on the tops of standards but they should overhang and be placed so that the angle of reflection of the light from the paper is thrown away from the eyes; but I advocate a simple, foolproof means of adjustment in order to accommodate the intensity of the light to the needs of the work or the idiosyncracies of the worker.

For drawing offices I must, as an architect, disagree with those who advocate general lighting. It may be argued that if we are satisfied with daylight we should find that a reasonably high degree of well-diffused general lighting would be practically as good. Daylight work is usually done under a window where one can nearly always find a light of at least 30 foot-candles, but to provide a general artificial illumination anything near that amount would be costly and objectionable. For ordinary work 5 or 6 foot-candles would be ample, but when examining or tracing faint or complicated plans, 15 to 30 foot-candles would not be too much. The best and most useful arrangement, therefore, is to have a treble-jointed arm attached to a bracket, standard or pendant carrying an opaque shaded 50-watt lamp, or an ordinary gas mantle, which can be moved over any part of the drawing board and raised or lowered so that any desired degree of illumination from 3 to 30 foot-candles may be brought to the work.

One objection raised to local lighting was the severity of contrast with the darker surroundings. Injurious contrasts exist only when the eye has continually to contend with bright and dark surfaces in the same area of vision, and this does not arise in local lighting. The Chairman told us that he preferred to work at an illuminated desk in a darkened room, and I, too, have found the same thing very comfortable. Authoritative opinions are quoted in THE ILLUMINATING ENGINEER commending the value of darkened surroundings to which the eyes may be occasionally turned for rest.

Matt surfaces to desks, etc., will afford little help in avoiding injurious reflections as a month or two's use would render glossy all that had not collected dirt; nor is there any writing-paper that will not reflect the bulk of the incidental rays at the corresponding angle, and there is the added risk that one is often unconscious of paper reflection until the damage is done. The remedy must be looked for in a system of thoroughly diffused lighting.

Mr. A. WISE, in reply, said that the discussion had led to a number of interesting points being raised. There was, however, some difference of opinion. Mr. Willcox had contended that the order of illumination in general use was much too low, and that 50 watts per person was not excessive. Mr. Cunnington, however, laid stress on the point that appealed to the user, namely, that it was just as important to avoid extravagance in light as too meagre illumination.

While there was a general conception of the amount of illumination necessary for reading and writing which he thought he had assessed pretty correctly at 4—6 foot-candles for office work, he agreed that fuller confirmatory evidence was necessary to place this value beyond dispute ; his idea had been to allow scope for variety in the form of work and the nature of the paper. With coloured paper, faint ink and indistinct handwriting he thought that six foot-candles was by no means excessive.

Mr. Willcox had referred to the distinction between semi-direct or " diffused " lighting. The speaker evidently recognised the same distinction that he (Mr. Wise) had emphasised in his paper. The term " semi-direct " was possibly not happy, but " diffused " lighting did not altogether describe a properly directed light. The author suggested that the distinction between the various nomenclatures in vogue be drawn on the following lines :—

Indirect Lighting.

Where the light source is obscured from view by some opaque material and the flux redirected upon the working plane from the ceiling or other reflector placed above the source.

Semi-indirect.

Where the light source is obscured by a diffusing medium and more than 50 per cent. of the light flux is directed into the zone above the horizontal axis of the unit, and thence redirected from the ceiling or other reflector placed above the source upon the working plane.

Semi-direct.

Where the light source is obscured by a diffusing medium and more than 50 per cent. of the light flux is directed into the zone below the horizontal axis of the unit.

Diffusing.—Where the light source is totally enclosed in a diffusing medium and the flux equally distributed in the zones above and below the horizontal axis of the unit.

Direct.—Where the light source is visible from the working plane.

He had been asked to give some fuller data regarding the relative consumptions with the various systems of lighting, the effects of reflection from walls and ceilings. In this connection the table on page 50, compiled by J. R. Cravath, gives the percentage of the flux delivered upon a 30-in. horizontal plane to the total flux produced by the illuminant.

From the table it will be noted that, all other conditions being equal, direct lighting with efficient reflectors is 40 per cent. more economical (from the point of view of current consumption than indirect lighting). Comparing this with an efficiency of approximately 40 per cent. from a semi-indirect unit we obtain the ratio :—

Direct : semi-direct : indirect : 1·0·8 : 0·6.

Mr. Willcox had dealt mainly with the advantages of indirect lighting. While he (Mr. Wise) agreed that this system was in many cases useful, for example in the particular problem of lighting drawing offices, he could not agree that it was the only one for general office lighting, and as a rule he preferred semi-direct methods. In his experience indirect lighting could not be described as " fool-proof," for it required considerable care in design and equipment, as well as efficient maintenance. The distance of the unit from the ceiling was often an important item, and it would be generally agreed that where indirect lighting was used the need for keeping both the fittings and the ceiling in a clean condition was exceptionally great ; it was in such matters as this that the negligent consumer defeated the aims of the lighting engineer. It was also a matter of common knowledge that there were certain types of rooms for which indirect lighting was ill-adapted.

Mr. Dennison had rightly emphasised the importance of avoiding excessive contrasts as well as glare. On the other hand there seemed some difference of opinion regarding the degree of contrast that was objectionable. Indeed, the President and Mr. Darch had rather expressed themselves in favour of subdued surroundings, on the ground that they were restful to the eye. He recalled that when Dr. James Kerr read a paper on this subject before the Society in 1917 the suggestion was made that the contrast between work and surroundings should not exceed 100 : 1. He had this figure in view (and also the Home Office Committee's recommendation on the ground of convenience and safety) in suggesting a minimum of one-tenth of a foot-candle on the floor, irrespective of the special illumination for work. In speaking of banks he had suggested a general illumination of 2 foot-candles, because he regarded this as part of the working illumination, and as a safeguard against inconvenient shadows.

TABLE SHOWING UTILISATION EFFICIENCY

(*i.e.* percentage of total flux of light received on a horizontal plane 30 inches above floor) for various systems of lighting.

Equipment.	Light-reflecting quality.		Shortest dimension (width or length) of room divided by height.	Percentage of total flux on working plane.
	Walls.	Ceiling.		
Direct: prismatic, or opal reflectors at ceiling.	Light	Light	3 or more	55—65
	Dark	Light	3 or more	50—60
	Light	Light	1—2·5	50—60
	Dark	Light	1—2·5	45—55
	Dark	Dark	1—2·5	30—40
Direct: frosted globes at ceiling ..	Light	Light	3 or more	35—45
	Dark	Light	3 or more	30—40
	Light	Light	1—2·5	30—40
	Dark	Light	1—2·5	25—35
	Dark	Dark	1—2·5	15—25
Direct: bare lamps at ceiling	Light	Light	3 or more	40—50
	Dark	Light	3 or more	37—47
	Light	Light	1—2·5	38—48
	Dark	Light	1—2·5	30—40
	Dark	Dark	1—2·5	20—30
Indirect: cove enamelled	Light	Light	3 or more	15—25
	Light	Light	1—2·5	10—20
Indirect: efficient conical reflectors on central fixtures	Light	Light	3 or more	34—44
	Dark	Light	3 or more	32—42
	Light	Light	1—2·5	30—40
	Dark	Light	1—2·5	25—35

Several speakers had referred to the lighting of typewriters. He agreed that, in large offices especially, it was preferable to rely upon well-diffused general lighting. As was well known pendants carrying angle lights were apt to become displaced, but if a two-cord pulley were used this would prevent the light swinging round. Mr. Garbett had suggested the use of shallow reflectors over bowls in order to diminish the dust difficulty. Such units were useful when no great reliance could be placed on the ceiling for reflecting purposes; but, naturally, they constituted direct lighting, and the advantage of diffusion from the white ceiling was largely lost. Mr. Willcox had advocated fuller use being made of the room structures to diffuse light. While pleasing effects could be secured in this way, success often depended in securing the willing co-operation of the architect—a matter to which attention had been drawn by Mr. Jones in the course of the discussion. He had insisted upon the advantages of using any available light surfaces in his paper, but, as Mr. Dennison

INDEX, February, 1919.

PAGE
Editorial. By L. Gaster 21
Headlights and Motor-vehicles in the War 52

Illuminating Engineering Society—
(Founded in London, 1909.)

Account of Meeting on January 21st 25
New Members 25
Modern Practice in Office Lighting. By **A. Wise** 27
Discussion :—
F. W. Willcox—R. Claude Bussell—J. H. Jones—F. S. Dennison—A. Cunnington—G. P. Garbett—O. L. Boyse—P. J. Waldram—J. S. Dow—The President (A. P. Trotter)—J. Darch—A. Wise 39
Illuminating Engineering Society in Japan, The 26
Lighting and Agriculture 52
Lighting of the World's Airways 52
Searchlights on Italian Aircraft 52

---

had said, it was difficult to induce consumers to keep such surfaces clean; if they did not do this the lighting installation soon deteriorated.

With regard to the lighting of racks, pigeon-holes, etc., he still thought that in most cases well-diffused general lighting was the best plan. Local lights for attachment to bookcases, etc., were available, but their use on a large scale was expensive; besides, the oblique nature of the rays did not give satisfactory results, especially at parts most remote from the light.

Much of the discussion had turned on the lighting of drawing offices. He found there was general agreement that for fine work local lighting was necessary. Such local lights should be adjustable according to the desires of the operator. The system of providing diffusing glass surfaces lighted from below, as mentioned by Mr. Willcox, gave excellent results in some cases. It was, however, expensive, and it would obviously require a very high illumination when working with thick drawing paper.

With regard to the small projection lamp, to which Mr. Dow had referred, it was a fact that no trouble from streakiness was experienced, in spite of the coils of the filament not being in the same plane; he ascribed this to the fact that there were no visible gaps between the filaments; even if the more remote portions were out of focus they did not give streaks. He hoped that this type of lamp would be adapted to small portable lantern outfits as Mr. Dow had suggested.

In conclusion Mr. Wise said that although there were some points on which fuller confirmation was needed, and others which were necessarily subject to personal taste, he thought there were sufficiently agreed principles to enable some simple recommendations on office lighting to be drafted. Such matters as the avoidance of glare and inconvenient shadows, the provision of sufficient illumination, the importance of cleanliness, and the avoidance of unduly polished wall surfaces and undesirable qualities of paper might well be emphasised. He suggested that these might form the subject of a short series of recommendations to be issued by the Society.

LIGHTING AND AGRICULTURE.

In a paper read by Dr. J. F. Crowley before the Royal Society of Arts on February 19th an interesting account was given of the applications of electricity in agriculture. Of special importance is the use of electric lighting in farm buildings, barns, cowsheds, etc. There is now no reason why such buildings should be left in the semi-darkness that is still frequent in rural districts.

In Germany the larger farms have their own electric supply and many country districts are covered by a network of high tension wires from which current can be tapped and transformed down to ordinary voltages for use in buildings. In many cases, too, portable motors can be fed from movable vans equipped with the transforming outfit, and each implement can carry with it appropriate lighting appliances to enable work to be done by night.

In those cases where neither electricity nor gas is available there remain many useful methods of producing a powerful light such as the portable incandescent oil lamps to which reference has often been made in these columns. Such lamps can be carried from place to place by hand, while lighted, and should therefore be specially useful on farms.

SEARCHLIGHT EQUIPMENT ON ITALIAN AIRCRAFT.

In the *Oesterreichische Flug-Zeitschrift* an account was given some months ago of the searchlight equipment of Italian aircraft, attention being devoted mainly to the source of power. A battery may be used, but this is not often the case owing to the weight. A more common arrangement is a dynamo working in conjunction with a steadying battery of small capacity. The total weight, including dynamo, controlling apparatus, accumulators, lamp and reflector, amounts to approximately 30 kg. The searchlight is used mainly to illuminate the ground in starting and landing during night flights.

HEADLIGHTS FOR MOTOR VEHICLES IN WAR TIME.

The arrangement of the headlights on motor-cars operating in the war regions has been carefully studied, but it appears that no entirely satisfactory arrangement, enabling the driver to see his way and yet giving no indication of movement to the enemy, has yet been devised. In *Der Motorwagen* the chief requirements for field service are summarised as follows :—

(1) The headlight must be invisible to the enemy.

(2) The road must be lighted over a short stretch sufficiently for driving purposes.

(3) The light must not be such as to dazzle the eyes of the driver and prevent him seeing for long distances. In addition the headlight should be capable of being completely extinguished at any minute in case of emergency.

LIGHTING THE WORLD'S AIRWAYS.

A note on the above subject recently appeared in *The New Illustrated* which gives some interesting particulars of night signalling for aircraft during the war, and discusses the future methods of illumination for the benefit of aircraft on peaceful missions. During the war the British, it is stated, relied chiefly on land lighthouses, each flashing a different code number, as an indication of locality. In addition the Germans also employed permanent coloured flares, stationary searchlight beams, and "flaming onion" sprays flung upward to an immense height. From a machine flying at a height of 10,000 feet over the Straits of Dover the "green ball" sprays at Denis Westram and Gontrode (50—60 miles away) were often seen quite clearly.

In the future the lighting of the world's airways by night will be a most important problem. Possibly many different methods may be used—group searchlights at the coast indicating Custom House landing grounds, lighted seadromes to dispatch aeroplanes at all hours of the night, coloured flares and rockets, land lighthouses and illuminated ground screens will all play their part in marking out the main highways of the world.

The
ILLUMINATING
ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

The Lighting of Railways.

It is now just about seven years since the Illuminating Engineering Society first dealt with the lighting of railways in a discussion opened by Mr. Haydn T. Harrison, on December 19th, 1911. On that occasion a variety of data was presented, and some tentative indications of possible standards for platform illumination were suggested in the discussion. With the cessation of hostilities, and the resumption of normal lighting on the railways, the moment was considered opportune to reopen the subject, and Mr. A. Cunnington, Lighting Engineer to the London and South Western Railway, was invited to read a paper on " Railway Lighting and its Maintenance " before the Society, on February 25th. The complete paper and discussion is given in the present issue (pp. 59—88). In the course of his investigations Mr. Cunnington has had occasion to deal with all illuminants, and we think our readers will agree that he has presented a most informative and suggestive paper. The evidence it affords of a practical grasp of railway lighting problems, as well as the fundamental principles of illuminating engineering is the more gratifying to us because Mr. Cunnington, before taking up his position with the L. and S W. Rly., was directly associated with us in the conduct of THE ILLUMINATING ENGINEER.

On railways, it is truly pointed out, the cost of lighting is a considerable item, in view of the large areas to be dealt with. It is therefore vital that no light should be wasted, and that the use of the most efficient lighting appliances and the proper placing of lamps should be carefully studied. It is obvious that the conditions are best secured when the lighting as a whole is under one common direction, and we hope that the enterprising step taken by the London and South Western Railway of appointing special experts to deal with all these problems will be followed by others. Even when this is done the avoidance of overlapping between various departments needs attention. It was, for example, pointed out in the discussion that in some cases the architectural features are settled before the consideration of lighting, and the lighting expert is only called in when the building or structure is complete. Needless to say, this handicaps the lighting engineer considerably, and prevents the most efficient and suitable conditions of illumination being realised. One can readily appreciate, for example, how convenient it is for the lighting engineer to be able to arrange at an early stage for recesses in the roof of a long corridor wherein lamps can be concealed from the eye, while lighting the floor ; thus avoiding the inconvenient glaring effect of a long row of exposed lamps. A similar case that came under our notice recently was the installation of a boxed-in stand carrying time-tables for the inspection of the public. The department responsible for the fitting up of these tables apparently imagined that the general illumination on the station platform would be sufficient—which was not the case. Had the lighting expert been consulted before the tables were planned it would probably have been quite feasible to place the paper time-tables on glass sheets, and illuminate them by light transmitted from below.

It is common knowledge, also, that on some railways the lighting of carriages and of station platforms, etc., is controlled by entirely separate departments. One of the speakers in the discussion even mentioned a railway on which the traffic department was responsible for mantles and the engineer's department for cleaning the burners. Such cases probably arise through sections of the lighting being allotted indiscriminately to different departments as they arise. This method is surely quite out of date now ; if it is convenient to delegate different sections of lighting to different departments there should, in our opinion, be adequate supervision by a special lighting expert so that the engineers in all these departments can be kept fully informed of the latest developments in lighting. Another source of inefficiency is the fact that in some cases the recommendations of the engineer concerned with lighting are referred to a general committee, which deals broadly with administrative problems or expenses, but possesses no special knowledge of illumination.

We have remarked upon the importance of a careful control of the use of light on railways in the interests of economy. But we need hardly say that this is only one aspect of the subject. The first and essential claim in our opinion is that the lighting should be adequate in the interests of safety and efficient work, while we also believe that good lighting in relation to the convenience of passengers is a most valuable asset to the railway company. There are many lighting devices which were considered luxuries a few years ago, but are now already becoming recognised as necessities. As instances we may mention the use of illuminated notice-boards indicating the destinations, departure platforms and times of departure of trains, and the provision of properly lighted nameplates for stations, whereby the passenger can quickly recognise the station at which he has arrived. We believe that the saving in time and inconvenience following the adoption of such devices well repays the small expense involved, and we hope that the next step will be the general provision of properly illuminated time-tables.

Apart from such special devices, the general standard of illumination has undoubtedly risen greatly during recent years. Mr. Cunnington presents a diagram showing how the amount of light in railway carriages has increased during the period 1890—1900—1910. We have no doubt that there has also been a substantial advance in the lighting of railway platforms, goods yards, etc. There are, however, admittedly many instances in which railway companies have fallen behind the general advance of their more enterprising brethren, and probably on all railways there are some stations, yards, or workshops which have not yet received their proper quota of illumination. It is, however, now recognised that the provision of a sufficient illumination is only part of the problem. The proper selection and spacing of lighting fittings in order to secure reasonable uniformity of illumination, absence of glare, and elimination of inconvenient shadows is equally important.

The data supplied in Mr. Cunnington's paper carry us a considerable step further towards the prescription of definite conditions of lighting, for platforms, goods yards, goods sheds, etc. Naturally the conditions of illumination will vary according to the importance of the station, goods yard, etc., and he has accordingly divided such areas into classes in order of importance. What is now needed is to acquire similar complete data for the chief railway systems, assembled on a uniform plan, with a view to preparing definite recommendations on railway lighting. Some difference of opinion was expressed at the meeting regarding the method of measurement in various cases (*e.g.*, whether illumination should be measured in a vertical or horizontal plane, or, if the latter, whether on the ground level or three feet above it). These questions would need to be first determined before preparing the requisite data.

It is proposed, therefore, that all these questions should be referred to a joint committee to be appointed by the Society on which both the Society and the chief railway companies should be represented, and we should also like to see included a representative of the London "Safety First" Council, in view of the great attention which this body has paid to the question of lighting in relation to safety, obviously a most important aspect on railway systems. By the aid of the information collected the Committee should soon be able to present some general recommendations on railway lighting, leading to acceptable standards of efficiency, and it should also remain permanently in being in order to deal with any future problems that may arise.

Gas, Electricity and Illuminating Engineering.

In a comprehensive paper on "The Distribution of Light, Heat and Power by Electricity," before the Royal Society of Arts on March 19th, Sir Dugald Clerk, K.B.E., drew an interesting comparison between the thermal efficiencies attainable by using gas and electricity for light, heat and power.

Regarded from this standpoint, Sir Dugald Clerk showed that so far as lighting is concerned, there is little difference between the two methods. Similarly, in regard to general results obtainable, it seems now to be accepted that there is not a very great margin of difference between the two illuminants, if the latest and most efficient methods of using both are compared.

The trend of events, therefore, confirms the opinion that we have consistently expressed, that there is ample room for both illuminants, and that the decision in any particular case will be guided by special circumstances, and especially by the enterprise shown by representatives of gas and electric lighting in adapting their illuminant to the purpose in view. Nothing has been more interesting in the history of lighting than the way in which each effort by gas has called forth a corresponding advance in electric lighting, and *vice versa.* Although, in the future, new discoveries may in turn favour one or the other, it seems likely that the balance will not be materially disturbed for some time to come. Lord Moulton, who presided on the occasion of Sir Dugald Clerk's paper, made some interesting speculations on the future efficiency of gas lighting. He remarked that the fact that the atmosphere contained four parts of nitrogen (which was merely "clinker" so far as combustion is concerned) was one obstacle to immediate progress. No one, however, can tell what the future has in store. As a balancing advantage it might perhaps be urged that the radiant efficiency (percentage of energy radiated as light) of the incandescent gas burner is, according to some authorities, considerably less than that of the electric arc or filament, and that therefore the theoretical margin for *ultimate* improvement is correspondingly greater.

But in any case the immediate future is such as to favour co-operation between the gas and electric industries, both in regard to problems of manufacture and distribution and in the study of the best use of the light thus made available to the public. Sir Dugald Clerk showed a complete recognition of the interdependence of the gas and electric industries. "Engineers of the gas industry," he said, "fully recognise the important position now filled by the distribution of electricity from central stations; and they wish to co-operate with electrical engineers in producing the necessary electrical supplies in the manner best calculated to conserve the vital coal resources of the country. They desire to point out, however, that gas and electricity are both required for the purposes of our civilisation; and that for progress in both industries it is necessary for them to develop in friendly rivalry, each performing the task for which each system is specially suited."

In the field of illuminating engineering the advantages of such co-operation have been made manifest during the past ten years. Gas and electrical engineers have gained much information at meetings of the Illuminating Engineering Society which both could easily apply. The most useful asset which a representative of either illuminant can possess is a knowledge of the principles of illumination and the art of using light to the best advantage.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

SOME NOTES ON RAILWAY LIGHTING AND ITS MAINTENANCE.

(Proceedings at a Meeting of the Society held at the House of the Royal Society of Arts. 18, John Street, Adelphi, W., at 8 p.m. on Tuesday, February 25th, 1919.)

A MEETING of the Illuminating Engineering Society was held at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, February 25th, the President (Mr. A. P. Trotter) in the Chair.

The minutes of the last meeting having been taken as read the Hon. Secretary read out the names of the following new applicants for membership:—

Vice-Presidents :—

Sir Anderson Critchett, Bart., K.C.V.O., President of the Council of British Ophthalmologists, 21, Harley Street, London, W.

Mr. H. J. Cash, President of the Electrical Contractors' Association, Caxton House, Westminster, S.W.1.

Ordinary Members :—

Arundel, Sapper N. E. V. ..	Electrical Engineer, Education Staff, New Zealand Expeditionary Force, Germany.
Bannister, Chas. J.	Electrical Engineer, 32, Deodar Road, Putney, S.W.15.
Beaver, A. G.	General Manager of the Sun Electrical Co., Ltd., 118-120, Charing Cross Road, London, W.C.

The HON. SECRETARY then read out for the second time the names of applicants for membership announced at the previous meeting on January 21st, 1919,* and these gentlemen were formally declared members of the Society.

Attention was drawn to the new arrangement, similar to that already entered into with the Institutions of Gas and Electrical Engineers, whereby the Presidents of the Council of British

---

* ILLUM. ENG., Feb., 1919, p. 25.

Brereton, Lieut. Ll.	Electrical Engineer, Canada.
Grubb, J. Archer	Electrical Engineer, " Rosslyn," Sydney Road, New Southgate, N.11.
Hughes, C.	Electrical Engineer, Messrs. Siemens Bros. Dynamo Works, Ltd., 39, Upper Thames Street, London, E.C.
Kelly, J. J.	Electrical Engineer, Messrs. Siemens Bros. Dynamo Works, Ltd., 39, Upper Thames Street, London, E.C.
Lofts, J. W.	Engineer, Messrs. W. Sugg and Co., Ltd., Chapter Street, Westminster, S.W.
MacCallion, Capt. W. J. ..	Electrical Engineer, Dept. of Public Works, Sydney, Australia.
Mattock, W. G. H.	General Manager, Messrs. W. Sugg and Co., Ltd., Regency Street, Westminster, S.W.
Morton, E. R.	Works Manager, The Sun Electrical Co., Ltd., 118-120, Charing Cross Road, London, W.C.
Perry, V. J.	Departmental Manager, The Sun Electrical Co., Ltd., 118-120, Charing Cross Road, London, W.C.
Ratcliff, H. A.	Chief Electro-technical Assistant, Manchester Corporation Electricity Works, Manchester.
Sawyer, G.	Messrs. W. Sugg and Co., Ltd., Regency Street, Westminster, S.W.1.

Ophthalmologists and the Electrical Contractors' Association would become Vice-Presidents and members of Council of the Society during their tenure of office. Sir Anderson Critchett, Bart., K.C.V.O., and Mr. H. J. Cash, the Presidents of the two bodies referred to, had kindly consented to act in this capacity, and it was hoped that the arrangement would be helpful in facilitating co-operation on matters of mutual interest.

The President then called upon Mr. A. Cunnington (Lighting Engineer to the London and South Western Railway) to read his paper entitled "**Some Notes on Railway Lighting and its Maintenance.**"

A discussion then ensued in which the following took part: Mr. Haydn T. Harrison, Mr. J. H. Haigh (Lancashire and Yorkshire Railway), Mr. A. H. Stevens (London and North Western Railway), Mr. P. Whysall (Underground Electric Railways Ltd.), Mr. H. Perkin (Great Central Railway), Mr. F. W. Goodenough, Mr. A. Wise, and Mr. H. E. Robarts (South Eastern and Chatham Railway), took part. Engineers associated with other railways intimated their intention of contributing written contributions to the discussion.

After Mr. Cunnington had briefly replied to the discussion, The President announced that, in accordance with the intimation sent to members, the **Tenth Anniversary Dinner** would be held on **Tuesday, March 18th,** when it was hoped that members would make a special effort to attend.

It was also announced that the **next meeting** would be held on **Tuesday, April 8th,** when a discussion on "**Light and Colour in Relation to Stage Productions**" would be opened by **Mr. J. B. Fagan,** of the Court Theatre.

SOME NOTES ON RAILWAY LIGHTING AND ITS MAINTENANCE

By A. CUNNINGTON (Lighting Engineer to the London & South Western Railway).

(Paper to be presented at a meeting held at the House of the Royal Society of Arts, John Street, Adelphi, London, W., on Tuesday, February 25th, 1919.)

ILLUMINATING engineering, as represented by the work of this Society during the last ten years, has been largely concerned with putting forward ideals in lighting. Its success can be judged from the evidence on all hands of improved standards of illumination and increased interest in and demand for good lighting; and this is perhaps nowhere more strikingly displayed than in the field of railway lighting. The keenness of the railway working staff to get the best possible lighting for their work has probably been noticed by most railway engineers, and it has been especially evident since air-raid restrictions have been relaxed. It is always the aim of the lighting engineer to satisfy this demand for good lighting, because it is realised that on it depend largely not only the safety and health of the workers, but also the speed and general efficiency of working. Again, from the passengers' point of view a distinct improvement is noticeable, and we find many a lighting device which at first was looked upon as a luxurious innovation now regarded as a necessity.

Perhaps it would not be out of place to give here some figures which I have been able to obtain showing the remarkable increase in the illumination of railway carriages in the last 25 or 30 years (see Fig. 1). The measurements show the illumination in the middle of a compartment at the ordinary level of a book or newspaper under (a) colza oil, (b) flat flame gas burner, (c) mantle gas burner (Pintsch's gas), or electric filament lamp. As an approximation, these systems of illumination can, I think, be associated with the decades 1890, 1900, and 1910. The rapid upward rise of the curve may be taken as typical of the general tendency in standards of illumination and of the increasing interest in lighting matters.

The lighting engineer is, however, concerned not only in striving for the ideal light but in securing it for the least cost, and in any notes on the subject of railway lighting the question of cost must not be overlooked. In reading the discussion of Mr. Haydn Harrison's paper on Railway Lighting presented to this Society seven years ago, one is struck with the way in which a good many speakers appeared to overlook the fact that light on a railway is for use and not for ornament, or, to put it another way, is for working the traffic rather than for attracting custom. I am quite aware that in some circumstances a well-lighted station is a good advertisement, but what I wish to

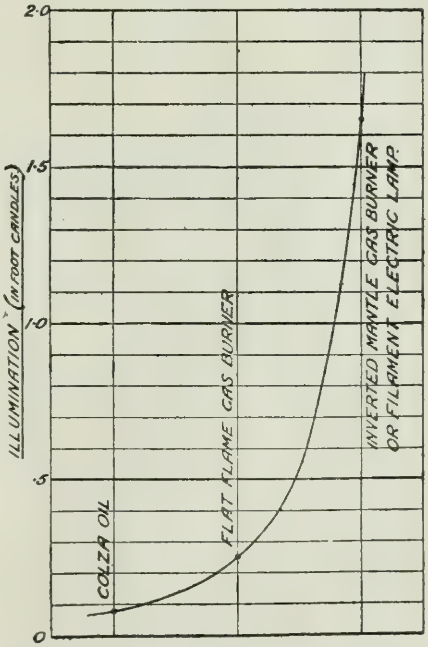


FIG. 1.—Showing progressive increase in Railway Carriage Illumination since about 1890.

emphasise is that extravagant standards in the near future may have to be resisted by the lighting engineer as keenly as he has pressed for improved standards in the past. The gradual cheapening of illuminants has had a great and beneficent influence in raising standards of illumination, but surely the time will soon come, if it has not already arrived, when we may expect to call a halt in this direction and utilise the increased efficiency in reduction of cost; or perhaps one should say in view of war-time experiences, in avoiding an increase in cost. When very large areas are to be lighted this question of cost is often a vital consideration. On the other hand, in considering the expenditure on illumination, the ratio (often small) it bears to the total cost of equipment should be scrutinised and the needs as regards safety and efficiency of work should not be allowed to suffer.

After noting certain general considerations, I propose to deal successively with various phases of railway lighting, first setting forth the standards and conditions that should be aimed at, and then drawing attention to practical difficulties which may necessitate some departure from the ideal. In order to keep the paper within bounds I shall not refer to the lighting of railway carriages, which is a very specialised branch, nor to signal lighting. It is hardly possible to deal with the special features of lighting in Tube railways, nor is this so necessary in view of the large amount of attention the subject received at the meeting of the Society in 1912. In general the war-time restrictions, first due to air-raid dangers, and since then to the necessity for fuel economy, will not be taken into account, and all illumination measurements given in the paper represent normal conditions.

GENERAL CONSIDERATIONS.

Importance of Maintenance.

Maintenance costs are a far more important item in the total lighting bill than is often imagined. Statistics on one of the trunk railways show that the proportion of cost of maintenance to cost of illuminant was roughly 1 to 4 before the War, and the present-day figures would be nearer 1 to 2.

Standardisation.

In railway lighting, where burners and fittings are dealt with on a large scale, it is of the greatest importance to adhere as far as possible to a few standard types, and this makes for economy to such an extent that it is often a decisive factor when it is a question of judging between two systems of lighting. Of course a lighting department will make a point of testing thoroughly any new illuminant or fixture, but the new device will always have a much greater chance of being adopted if it does not run counter to standardisation. Fancy methods are often barred simply because the cost of upkeep would be excessive. The standardisation of burners for oil lighting is a simple matter, one or two types being sufficient for all purposes.

Use of Small Gas Mantles.

Where incandescent gas lighting is in use, there is an unmistakable tendency to standardise a small mantle, generally the "Medium" or No. 2 size, and it may be noted that this allows of ample flexibility in the candlepower of units by the use of one, two, three or more mantles in a lamp, without having recourse to different types and consequent possibility of confusion and mistakes. Small mantles are preferable for other reasons, among which may be mentioned their greater strength and the ease with which they can be handled; also the fact that with diminished pressure or quality of gas the falling off of candlepower is not so noticeable with these mantles, presumably because the small flame fits the mantle more readily than the large.

Reduction of Stock and Under-running of Electric Lamps.

With electric lighting it is very difficult to standardise lamps on account of the large number of different supply companies each with its own special voltage. On the railway referred to above there are no less than 12 different supply pressures ranging from 100 to 600 volts, and the complete series of pressures from 200 volts to 250 volts in steps of 10 volts are in use. Under these circumstances it will not be wondered at that an attempt has been made recently to reduce the stocks of lamps by omitting certain intermediate voltages and having recourse to underrunning or over-running of lamps having the nearest available voltage rating. In the case of gas-filled tungsten lamps slight under-running has been resorted to also in order to increase the life of the lamp. When a single lamp costs anything from 15s. to 20s. it is obvious that precautions must be taken to prevent premature breakage. As lamps of this type appear to fail more quickly when over-run than ordinary tungsten lamps, and as upward fluctuations of pressure might thus bring about their premature failure, it has been found advisable slightly to under-run these lamps, even though it means some little sacrifice of efficiency. This policy had ample justification as a war-time measure, when lamps were in use for many thousands of hours which could not have been replaced owing to shortage of stocks if only the average life had been secured.

Comparative tests of new lamps and lamps after 10,000 hours' burning, which I made recently, showed a falling-off in efficiency of 25 per cent., accounted for both by decrease in candlepower and increase of watts. Clearly it would not pay to run lamps to this extreme length of life when new ones are easily obtainable, but at the same time I think a good case can be made out for underrunning by 1 or 2 per cent., and thus securing increased life. High efficiency is not the only aim in lighting, and certainly, from the railway maintenance standpoint, length of life, which is only another word for reliability, is of equal importance.

Dispensing with Outer Globes.

Another way in which maintenance costs can be reduced is by dispensing with the outer globes of large outdoor lanterns when using filament electric lamps. Experience has shown beyond question that gas-filled tungsten lamps are entirely unaffected by weather, provided the surrounding reflector is designed so as to give a certain amount of protection. Two typical examples are shown in Fig. 2, the large lantern being for high candlepower lamps run in series, the smaller reflector being fitted with B.C. holder for small half-watt lamps. In neither case is any outer globe used. This economy in outer globes has also been practised with indoor gas burners where metal reflectors afford all the protection that is necessary. Probably some slight reduction in theoretical efficiency has resulted, but in dusty situations (and on a railway is there any place that is not dusty?) the gain in illumination due to the absence of dirty glass has easily compensated for this, and the reduction in stocks of glassware is an obvious gain from the maintenance point of view.

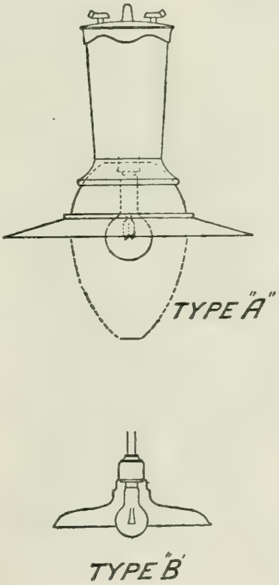


FIG. 2.—Fittings for Gas-filled Tungsten Lamps.

Type A for high candlepower lamps run in series.

Type B for low candlepower lamps.

Series Running of Electric Lamps.

Series running of electric lamps, although often necessary in order to secure the advantages of high voltage in distribution and to make use of half-watt lamps only as yet supplied for low pressure, is a distinct drawback in regard to upkeep. It usually necessitates keeping in stock lamps of some special voltage, and if good series running is to be preserved it is necessary to alter all the lamps when one fails, and the replacement gives opportunity for wrong lamps to be inserted by inexperienced attendants. The recent manufacture of gas-filled tungsten lamps over a wide range suitable for high voltages has made parallel running feasible in most cases, but according to my experience this introduces a curious phenomenon in regard to breakage which calls for some explanation. When these lamps are run in parallel the failure of one lamp in a circuit almost invariably blows the fuse of the circuit and this appears to be due to the fusing together of the leading-in wires with a consequent large reduction in the resistance of the lamp almost equivalent to a short circuit. A great part of the interior of the lamp is destroyed. On the other hand, with lamps in series, the failure of a lamp usually means nothing more than a parting of the filament, and though the circuit is interrupted the fuse is unaffected. A probable explanation is that filaments are stouter in the lamps run in series, and the effects cited above may be due to differences of filament only and not connected in any way with the system on which the lamps are run, but definite information on this subject from lamp makers or others would be welcome.

STATION PLATFORMS.

Definite Standards of Illumination.

It has already been suggested that on a previous occasion when the subject of platform illumination was considered by the Illuminating Engineering Society, the standards indicated by several speakers were considerably in excess of what might be termed practical values. In attempting to arrive at definite figures we are fortunate in having now available a very large number of actual measured values of illumination. By selecting from these the figures for stations which by common consent are well lighted and have satisfied those who have to use them and to work in them, it is possible to form a much more useful estimate of the desirable illumination than can be obtained by mere surmise. This I have endeavoured to do, and have adopted the very useful classification of stations suggested by Mr. Herbert Jones in the discussion on Mr. Harrison's paper, viz. :—

Class I. Terminal stations usually completely roofed over with high roofs.

Class II. Important junctions usually with low roofs over the platforms only.

Class III. Less important and wayside stations, usually having a short length of roof, and "beacon" lighting beyond.

On the basis of this classification, I have set out in Table I. a number of illumination values taken from the test records of the L. & S.W.R. They are placed in descending order of minimum illumination for each class.

In Table II. the average values in round figures both of minimum illumination and of illumination ratio are given, and these it is suggested might well be taken as fair standards for station

TABLE II.

AVERAGE VALUES DEDUCED FROM TABLE I. (p. 63)

Class.	Minimum Horizontal Illumination at 3 feet above Platform (in Foot-candles).	Illumination Ratio (Maximum/Minimum).	Remarks.
I.	0·5	3	——
II.	0·25	10	Test No. 10 omitted.
III.	0·035	13	——
III. (gas)	0·06	20	——
III. (oil)	0·01	6	Low ratio due to close spacing and shadow of lamp case.

NOTE.—Figures *outside* roof are only used where those for *under* roof are not available.

VALUES OF HORIZONTAL ILLUMINATION ON STATION PLATFORMS.

No.	Class.	Illuminant.	Type of Lamps.	Horizontal Illumination in Foot-candles at 3 ft. above Platform.						Remarks.
				Under Roof.			Outside Roof.			
				Max.	Min.	Ratio.	Max.	Min.	Ratio.	
1	I.	Electricity	Gas-filled tungsten	1·5	0·48	3·1	—	—	—	—
2	II.	Electricity	Vacuum tungsten	1·1	0·60	1·8	—	—	—	—
3	II.	Electricity	Vacuum tungsten	0·8	0·35	2·3	—	—	—	—
4	II.	Gas	Inverted mantle	2·6	0·25	10·4	—	—	—	—
5	II.	Gas	Inverted mantle	6·0	0·20	30·0	—	—	—	—
6	II.	Electricity	Vacuum tungsten	0·9	0·20	4·5	—	—	—	—
7	II.	Gas	Inverted mantle	2·5	0·15	16·7	—	—	—	—
8	II.	Gas	Inverted mantle	1·5	0·15	10·0	1·4	0·015	93·3	Outside lamps wide apart and fixed low.
9	II.	Gas	Inverted mantle	1·0	0·10	10·0	—	—	—	—
10	II.	Gas	Inverted mantle	2·0	0·09	22·2	2·0	0·022	91·0	Ditto
11	III.	Gas	Inverted mantle	1·5	0·080	18·8	—	—	—	—
12	III.	Gas	Inverted mantle	0·5	0·080	6·2	—	—	—	—
13	III.	Gas	Inverted mantle	0·6	0·075	8·0	—	—	—	—
14	III.	Gas	Upright mantle	0·9	0·070	12·8	0·9	0·014	64·0	Outside lamps wide apart and fixed low.
15	III.	Gas	Inverted mantle	2·7	0·050	54·0	—	—	—	Lamps wide apart.
16	III.	Gas	Upright mantle	0·3	0·014	21·4	—	—	—	—
17	III.	Oil	Duplex burner	0·2	0·025	8·0	0·02	0·005	4·0	—
18	III.	Oil	Duplex burner	0·03	0·012	2·5	0·06	0·010	6·0	—
19	III.	Oil	Duplex burner	—	—	—	0·045	0·010	4·5	Minimum illumination increased to 0·20 by light of train.
20	III.	Oil	Duplex burner	—	—	—	0·017	0·010	1·7	—
21	III.	Oil	Duplex burner	—	—	—	0·065	0·005	13·0	—
22	III.	Oil	Duplex burner	—	—	—	0·03	0·005	6·0	—

lighting. It is interesting to note that the average value of 0·25 foot-candle arrived at for stations of Class II. is the same as the minimum value tentatively suggested in Mr. Harrison's paper of 1912 (though the average of the figures he then tabulated worked out at 0·315 foot-candle). It also coincides with the minimum for factories prescribed by the Home Office Departmental Committee on Factory Lighting, so that with all this confirmatory evidence, it is safe to assume that it really represents a good working standard.

Illumination Ratio.

In specifying platform illumination a statement not only of the minimum value but of the illumination ratio is essential. The latter is of great importance because it is the criterion of uniformity, and judging by experience a high degree of uniformity is greatly to be desired. It has frequently been proved that when the illumination provided is fairly uniform a considerably lower maximum (and therefore average) illumination will suffice, with a corresponding decrease in cost. A good example of this is seen in a change that was made at an important station some years ago. Old-fashioned arc lamps at very wide intervals were replaced by tungsten lamps with much closer spacing, and the resultant improvement in illumination is shown in Fig. 3.

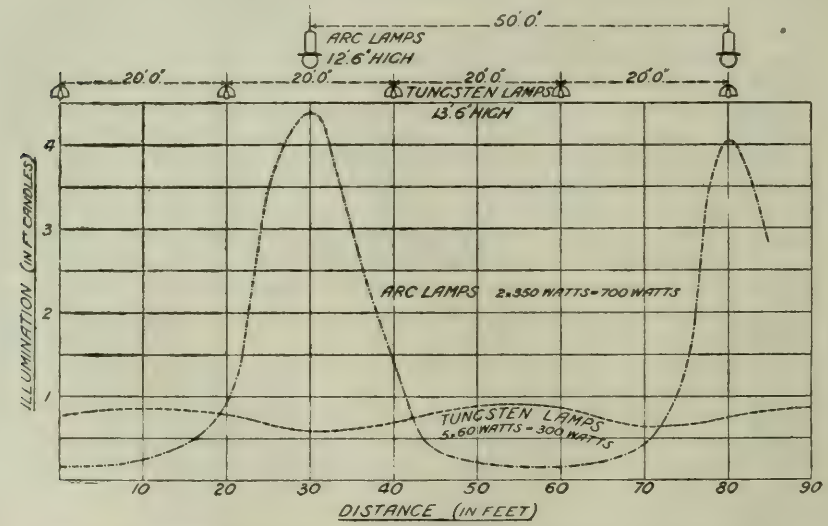


FIG. 3.—Showing Comparative Distribution of Illumination under Arc Lamps and Tungsten Lamps.

N.B.—Illumination measured in each case at 3 ft. above the ground along a line immediately under the lamps.

Height at which Illumination is Measured.

As regards the height at which illumination measurements should be made, we have found 3 ft. above the ground to afford the most useful information. It is an average height at which luggage labels, etc., have to be read, approximately the level at which tickets are held and roughly the height of carriage door-handles. This practice is in line with that adopted by the Street Lighting Committee when making measurements under very similar conditions, although they adopted the more universal unit of 1 metre. In any case, it may be noted that it has been found advisable frequently to supplement figures at this height with measurements made at platform level in any places of low illumination where it is important that the edge of the platform or obstructions on it should be clearly defined.

Miscellaneous Requirements in Platform Lighting.

There are some other desiderata for platform lighting which may be briefly touched upon. Special local lighting should always be provided for ticket collecting barriers and for time-tables. As regards the collecting of tickets, it is quite usual to find special lamps in use, in fact, were this not so the general standard of illumination would have to be unnecessarily high, as not less than 2 foot-candles is desirable where any large number of tickets has to be dealt with. In the matter of time-tables much can be done in the way of local screened lighting when the authorities arrange to group time-tables in a few convenient places instead of scattering them over the station walls as is, unfortunately, often the case. Name-boards and name-plates should be well lighted, and increased attention has been given to this matter recently since air-raid restrictions have been removed. A new problem arises with the use of lamps in circular steel reflectors, as to how to provide a suitable name-plate when there is no glazed lantern. Pendant plates are not very satisfactory and it seems probable that the provision of a fair number of independent illuminated name-boards would be a better solution than interfering with the platform lighting units.

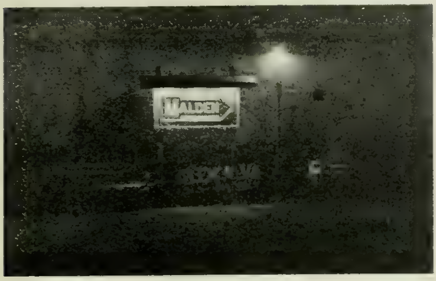


FIG. 4.—Showing simple arrangement for lighting a station name plate.

Fig. 4 shows a simple arrangement for illuminating a name-board which has been found effective.

Arrangement and Spacing of Units.

It is clear that in practice platform lighting has to be largely moulded

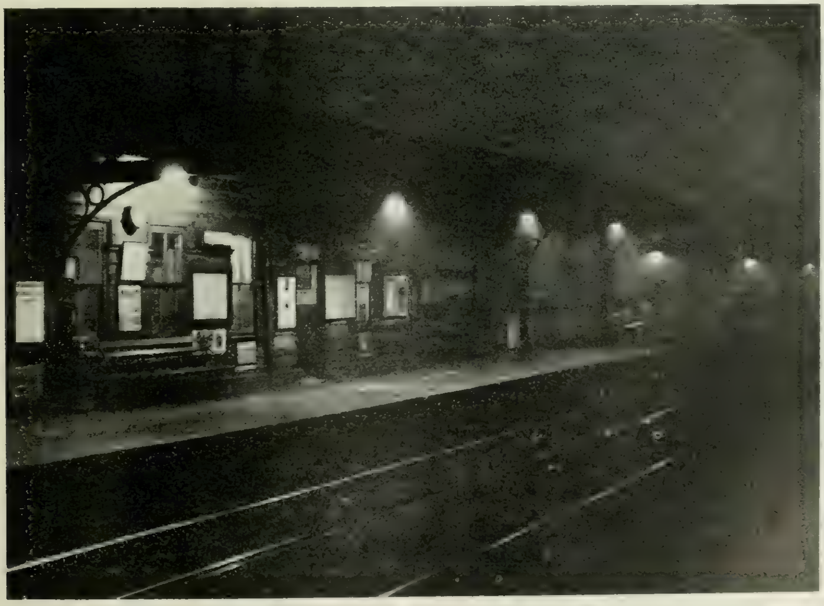


FIG. 5.—View of a station platform by night, showing even illumination secured by appropriate spacing of lamps in reflectors.

according to constructional details, and this is especially so under the typical low roof of the verandah type. Here the spacing is generally settled by the distance apart of the columns supporting the roof, and the height is limited by head room on the one hand and the roof itself on the other. For the large number of stations coming under Class II. there is no doubt that an arrangement of frequent small units is desirable. This gives uniformity of illumination and also allows of the use of reflectors which cut off the direct rays of the lamps at a point well below the horizontal and thus avoid glare. The absence of glare, coupled with uniformity of lighting to which reference has already been made, is not only correct lighting, but it makes possible a lower figure of illumination than would otherwise be necessary and is therefore economically sound. With electric lighting it is comparatively easy to arrange for a considerable number of units of not very high candlepower and this system is in use on some of the L. & S.W.R. suburban stations.

Fig. 5 shows a view of one of these stations taken at night.

Fig. 6 is a daylight view showing the arrangement of the reflectors under the roofing in the station of which Fig. 3 is the illumination diagram. Such an arrangement is hardly suitable for gas lighting as the units must each be more or less weatherproof, and in order to keep down both initial cost and maintenance it has been found advisable to concentrate the candlepower in fewer units. This arrangement has, however, many disadvantages from the illumination point of view, and I am convinced that there is a wide field for the introduction of a small gas lamp fitted for a single medium mantle and provided with a reflector properly designed for close spacing. Such a lamp would have to be wind-proof, but as it would be used under roofing there would be no need to add to the cost by making it absolutely weather-proof.

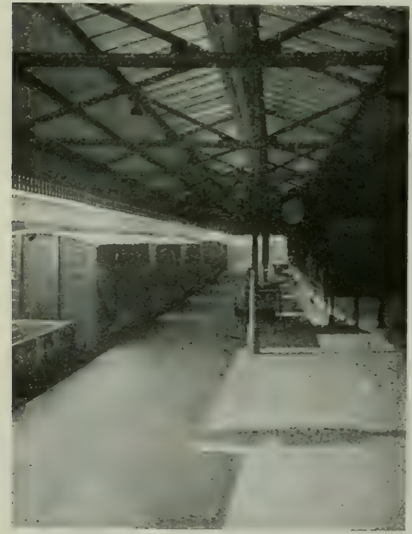


FIG. 6.—Daylight view of station showing arrangement of reflectors mounted under roofing.

An experimental gas-lamp of the type referred to above and designed by Messrs. W. Sugg and Co. was exhibited at the meeting.

Platforms with "Beacon" Lighting.

For the part of the platforms beyond the roofing it is not usual to provide anything more than "beacon" lighting, and this is quite satisfactory, for the lighting of the train itself supplements the platform lighting just when it is required. Furthermore, at stations of Class III. the interval between trains is usually long, and the traffic would rarely be sufficient to justify any elaborate system of controlled lighting to give a high illumination while a train is at a platform and reduce to a low figure between trains. Mr. Haydn Harrison, who was responsible for this suggestion, gave as suitable limits minima of 0·25 and 0·05 foot-candles respectively, but it must be pointed out that stations of this class are nearly all lighted by oil, which practically rules out any such arrangement.

Pilot-flame Oil Lamps.

Oil lighting is of considerable importance to a railway company, for it must be remembered that a supply of gas or electricity is not available for the majority of wayside stations. It is possible, however, to instal pilot-flame oil lamps, and this has been done experimentally on one of the South Western stations with complete success. When fully turned up the burner is of the ordinary duplex pattern, but on pulling down a chain or lever a partial extinguishing device comes into action and the flame burns low with an oil consumption of about one-fourth of the normal. When the intervals between trains are long it is worth while to employ a device of this kind even though each lamp requires individual manipulation.

Petrol Air-gas, Acetylene, etc.

Where a wayside station having no local supply of gas or electricity happens to be of some importance, owing, perhaps, to being a junction, it becomes necessary to consider the use of acetylene, petrol air-gas or vaporised oil. Acetylene for regular station lighting could only be justified in exceptional cases on account of its high cost, but it has proved itself invaluable as an emergency light for dealing with temporarily increased traffic during war-time.

Acetylene hand-lamps have also been used for special purposes such as the inspection of tunnels, where a high candle-power is required, together with portability. I have not yet come across a lamp which quite comes up to one's ideal of what such a lamp should be, and any further information in this direction would be appreciated.

Petrol air-gas plants have been in use on the South Western Railway for many years, but they have proved somewhat costly to maintain. Unfortunately our experience has been confined to hot-air engine plants, and the comparison with a weight-driven plant cannot, therefore, be made. The latter method should be a check on wastage of gas by the station staff, for the men whose duty it was to wind up the weights would see to it that this was not done too often! Vaporised oil lamps are valuable for giving high candlepower at small cost, and have been found successful where proper attention has been paid to cleaning and maintenance generally, but where entirely unskilled labour is all that is available their upkeep is liable to be a source of trouble.

Control of Lighting.

Reference has already been made to the control of platform illumination by pilot-flame oil lamps. The question of control generally is an important one, for by the judicious arrangement of switches for reducing lighting when not in use a large measure of economy can be effected without in any way impairing the efficiency of the full lighting when it is required. Where electric lighting is installed, full advantage should be taken of switching possibilities. I have found that the simplest and best plan is to divide a row of lamps between two switches, placing alternate lamps on each switch. I am aware that Mr. Haydn Harrison in his paper* did not favour the turning out of intermediate light sources, apparently on the ground that the reduction was very uneven. I do not think this matters much if the units are fairly close together (say not more than 20 ft. apart or 40 ft. during half lighting), but what does matter very much is that the system of wiring and the lamp fittings should be simple and easy to instal and to maintain—in fact, should be wherever possible of standardised patterns. It may be well to remark here that the system of distance control can also be applied to gas lighting, and there are installations on the L. & S.W.R. which have given satisfaction for years. In this case the lamps are arranged alternately on separate supplies, one being in continuous use and the other turned out between trains. A special bypass service is run to the second group of lamps and mercury seals are fitted to prevent air getting back into the pipes.

Lighting of Roofs.

A good deal was said when the subject of railway lighting was last discussed before this Society on the question of lighting station roofs. It is hardly necessary to go over the ground again, but perhaps I may be allowed to express the personal opinion that if platforms are really well lighted the reflected light thrown from them on to the roof will in practically all cases be sufficient to avoid an undue appearance of gloom overhead, and I strongly advocate the use of reflectors which concentrate light on the platforms rather than fittings which allow a considerable flux of light to stray above the horizontal.

---

* See ILLUM. ENG., Vol. V., 1912, p. 31.

GOODS SHEDS.

Classification.

In dealing with this section of railway lighting it is at once advisable to distinguish between the different classes of work, such as receiving, loading, transfer, etc., of goods. On receiving platforms a high illumination is required throughout and uniformity should be aimed at, for it is necessary to be able to see labels and check consignment notes, which are frequently none too easy to decipher, and it is desirable that these should be readable at practically every part of the platform. In addition, however, to high general illumination, I am strongly in favour of providing small screened local lights close to the checking desks and scales. This avoids awkward shadows, which are almost sure to occur if the general illumination is relied upon for this purpose. For loading platforms the standard of illumination need not be so high as in the case of receiving or transfer of goods. An important point to be remembered in this class of lighting is that box wagons will often stand side by side with open trucks, and it is a great advantage in loading if the lighting is arranged so as to illuminate to some extent the interiors of these wagons.

Diversity of Conditions.

It is somewhat difficult to make any recommendations for definite standards of goods shed illumination owing to the great diversity of conditions. It is certainly necessary to establish a classification similar to that for station platforms, for it must be remembered that the importance of artificial lighting varies greatly according to the situation of the shed and the kind of traffic dealt with. Obviously a shed in a large town where working is almost continuous requires different consideration from one situated at a wayside station where the traffic is small and the shed is closed before dark for three-fourths of the year. As an extreme case of the latter kind I might instance a shed where one duplex oil lamp is in use, and it is the custom to bring the work to the light on the rare occasions when it is used. If it be urged that this is bad illuminating engineering, the reply is that the traffic does not warrant anything more elaborate. Such instances serve at any rate to establish the necessity for classification, and the three classes already indicated for platforms will probably suffice.

TABLE IV.

AVERAGE VALUES DEDUCED FROM TABLE III. (p. 69).

Class.	Minimum Horizontal Illumination at 3 feet above Platform (in Foot-candles).	Illumination Ratio (Maximum/Minimum).
I.	1·5	5
II.	0·45	5
III.	0·08	16

Minimum Values of Illumination.

Adopting this same classification, I have set out in Table III. a number of measured values of minimum illumination in goods sheds taken at random and arranged in descending order. Table IV. gives the average values in round figures for each class. It will be noticed that for Classes II. and III. the values are approximately double those found on station platforms. Assuming that these figures apply only to the ordinary loading platform in a goods shed, they might, I think, be taken as a basis for a standard minimum.

Practical Considerations.

There are several practical considerations which modify purely theoretical

TABLE III.

VALUES OF HORIZONTAL ILLUMINATION IN GOODS SHEDS.

No.	Class.	Illuminant.	Type of Lamp.	Horizontal Illumination in Foot-candles at 3 ft. above Platform.			Remarks.
				Max.	Min.	Ratio.	
1	I.	Electricity	Enclosed carbon arcs	7·0	1·5	4·7	General average about 2·5 foot-candles.
2	II.	Electricity	Vacuum tungsten	1·2	0·90	1·3	—
3	II.	Electricity	Gas-filled tungsten	1·1	0·58	1·9	—
4	II.	Electricity	Vacuum tungsten	1·45	0·40	3·6	—
5	II.	Electricity	Vacuum tungsten	1·1	0·16	6·9	Transfer shed.
6	II.	Gas	Inverted mantle	0·75	0·14	5·4	—
7	III.	Gas	Inverted mantle	1·7	0·11	15·4	—
8	III.	Gas	Inverted mantle	1·35	0·11	12·3	—
9	III.	Electricity	Vacuum tungsten	1·5	0·06	25·0	Wide spacing of lamps.
10	III.	Gas	Inverted mantle	0·4	0·03	13·3	Small number of lamps in use for a large area.

methods in shed lighting. For example, in many modern sheds, especially where there are several floors, the available head room is not sufficient to allow high candlepower units to be hung at their proper height. Unfortunately such units are often used in spite of this limitation, and the resultant illumination must of necessity be unsatisfactory. Again, large units fixed at a considerable height are almost certain to throw a good deal of light wastefully on cart-docks and spaces between platforms where no high illumination is required. Another difficulty that is met with when installing local lights for desks and scales is that of breakage. It is only necessary to watch the receiving platform of any large goods shed at the busy time of the day to realise the sort of vibration and jar that has to be allowed for. For this reason flat-flame burners were in use for years to provide supplementary lighting for scales in one of the L. & S. W. R. sheds. In all probability pendant incandescent gas burners with suitable anti-vibrating device would stand equally well judging by our experience of such burners in similar situations. Pendant electric lamps are also in use, and thanks to the strength of modern filaments these have withstood the severity of the conditions.

Difficulty of Glossy Paper, etc.

I should like to put in a plea here for more consideration from the Traffic Authorities on the question of lighting when they select the quality and colour of the paper used for consignment notes, etc. Cannot something be done to avoid faint copying-ink pencil on, say, green glossy paper ? To decipher this sort of thing is difficult even in daylight, let alone by artificial lighting. The question of glazed or matt paper was referred to at the last meeting, and its effect on reading is a matter that has been taken up by this Society. It would be well if these investigations bore fruit in the direction indicated.

GOODS YARDS.

Horizontal or Vertical Illumination.

In attempting to define standards for the illumination of goods or shunting yards a new question arises—whether minimum horizontal illumination, when taken alone and strictly adhered to, is really a suitable criterion. No doubt it would serve quite well if goods yards only contained isolated trucks moving to and fro, for then the conditions would be similar to street lighting, but one finds in actual practice row after row of wagons with only a few feet between them, and minimum illumination here would in most cases be below the limit of ordinary photometric measurement. Especially is this the case when a yard contains a number of road-box wagons or high refrigerator vans which necessarily cast deep shadows. To provide a reasonable minimum under such circumstances would require lamps between every running road, and the necessary clearance would not in most cases admit of this, apart from the question of cost. As a matter of fact the shunter always relies on his hand lamp even in the best-lighted yards, and it would be unreasonable to attempt to provide general illumination such as would obviate the use of hand lamps. For this reason I do not agree with Mr. Haydn Harrison's suggestion, in a former reference to this subject, that shunting yards require "large units erected as high as possible." I think Mr. C. R. Williams was much nearer the truth when in the discussion he advocated the concentration of lighting on points and crossings, *i.e.*, the principal working areas, with smaller lamps on comparatively short posts.

General or Local Lighting.

The question thus resolves itself into whether general or local illumination is the better. It must be borne in mind that it is at points and crossings that good illumination is essential, for it is here that the clearance of trucks has to be judged ; and the shunting of a second truck before the first is clear may lead to a derailment and great loss of time. To secure such an illumination as is required at these special points by means of a few high power units will almost certainly result in an extravagant illumination in other parts of the yard where so high a standard is not necessary. Under the system of local lighting the number of lamps to be maintained is greater, but as a set-off to this there is the increased reliability that is secured because there is less dependence on any single lamp.

Minimum Vertical Illumination

Another reason which makes horizontal illumination a doubtful criterion for goods yard lighting is the fact that in the majority of operations vertical illumination is what is really required. In addition to the reading of labels and shunting instructions on the sides of wagons (for which purpose hand lamps are almost invariably used) there is the more important consideration of seeing moving vehicles. I had occasion to make some measurements of illumination recently in connection with a case in which a man working in a yard was knocked down by a moving wagon. This had been shunted by an engine working in a darker part of the yard, and as the wagon, moving slowly, came out into the light it should have been seen by the shunter. His failure to see it was alleged to be due to poor lighting, but illumination measurements proved this to be unfounded. The interesting point established on this occasion was that a vertical illumination of only 0·01 foot-candle on the end of a wagon enabled it to be seen clearly. This was agreed to by a number of representative persons, including shunters, yard inspector, etc.

There seems to be here a suitable basis for defining minimum illumination in a goods yard, and I would throw out tentatively the suggestion that the vertical illumination measured in a plane at right angles to the direction of the sidings (and at 3 ft. above the ground, approximately buffer height) should not be less than 0·01 foot-candle. This would apply to any class of yard and any part of the yard where shunting is carried out. It would, of course, be necessary to supplement the above figure by a much higher minimum figure for the working areas, such as the "shunting neck" or the series of points leading into sidings in a gravitation yard. This latter figure might be graded to suit different classes of yards, but I should hesitate to make anything but a very broad classification, for we are faced here with the question of personal safety and any fine lines of demarcation would be out of place. It would probably be sufficient to distinguish between yards where only one shunting engine is in use and those where more than one engine is working. The ordinary small yard of a country station would come under the first class, whereas class two would include the more important yards at junction and terminal stations. I would suggest minima of 0·05 and 0·25 foot-candle for these respective classes. We have thus three minimum values :—

0·01 foot-candle—a universal minimum for any part of a yard where shunting is done.

0·05 foot-candle—a minimum for the working area in single engine yards.

0·25 foot-candle—a minimum for the working area in multiple engine yards.

I have intentionally placed the figures in ascending order because it seems to me that what I have called the "universal" minimum of 0·01 foot-candle is of the first importance. The other figures are purely tentative but are suggested by the results of actual measurements.

It has been suggested to me that some notes on the cost of providing the proposed minimum vertical illumination might be of interest to the meeting. I have worked out the approximate cost per 1,000 sq. yds. in a somewhat arbitrary manner, which will however serve to show that it is not an unreasonable demand. Assuming that a goods yard is usually longer than it is broad, I have taken the 1,000 sq. yds. to be a rectangle of, say, 40 by 25 yds. or 50 by 20 yds. in which case one lamp of from 200 to 250 candle-power would be required to give a minimum of 0·01 foot-candle in any vertical plane transversely over this area. The cost of this candle-power at present average rates for gas or electricity would work out at anything from ¾d. to 1d. per hour, or for a fairly busy yard where the lighting hours would be about 2,500 per annum, we might say the annual cost per 1,000 sq. yds. for this minimum illumination would be from £7 to £10.

It must not be assumed that an average of 200 candlepower per 1,000 sq. yds. will be found in practice, for it is clear that in any yard there are large areas where no shunting is done and the above minimum is therefore not required. On averaging out the candlepower per 1,000 sq. yds. for several goods yards of which I have particulars, I find the figure is usually about half that suggested. This might be arrived at on the following basis, which is, of course, only suggestive, but shows the proposed minimum to be quite reasonable and easily obtained in actual working :—For 80 per cent. of the yard (where no shunting is done), minimum equal to one quarter of the proposed value ; for 16 per cent. of the yard (working area), minimum equal to the proposed value ; for 4 per cent. of the yard (especially important area), minimum equal to four times the proposed value. The resultant minimum for the *total* area is in this case just half the figure for the *working* area.

It will be recognised that as in platform lighting the average values will be much higher than those specified owing to the nature of the lighting units which are available, and it is fairly safe to assume that if the minimum is strictly complied with the yard will be properly lighted. Exception may be taken to the use of vertical illumination at all, on the ground that horizontal illumination is important for showing up obstructions at ground level. It must be borne in mind, however, that vertical illumination is also valuable for this latter purpose ; and, furthermore, it would always be measurable, even when the horizontal illumination might have fallen below the range of a photometer. In general, I think a good case can be made out for treating goods yards as an exception to the general rule that minimum horizontal illumination should be specified.

Influence of Type of Lamp on Height and Spacing.

Although it is of interest to discuss theoretically the most suitable arrangement of lamps for yard lighting, it will be found that as far as existing yards are concerned it is the practical considerations which determine height and spacing. For example, where gas lighting is in use it is generally best to work with comparatively low candlepower units not more than about 20 feet above ground and to space them as frequently as the clearances will permit. It may be pointed out here that in many old yards there are comparatively few spots where there is room for a lamp, which consideration makes short work of theories as to spacing, but in modern lay-outs it is pleasing to note that provision is almost always made for the erection of lamp-posts in suitable positions. The tendency with electric lighting has been to go for very high candlepower units, laying, as I think, too much stress on electrical efficiency, *i.e.*, low running costs, and not regarding sufficiently the requirements of good lighting. The introduction of gas-filled tungsten lamps has resulted in the displacement of arc lamps to a large extent, chiefly, on account of reduced maintenance charges, and there is no longer any good ground (unless it be impossible to select sites for extra posts) for erecting lamps on sky-high masts, which for reasons already stated I do not consider satisfactory. High pressure gas lighting seems to stand between the extremes mentioned above and can be used effectively under the right conditions, but the upkeep of mains is liable to be a serious matter unless they are laid so as to be accessible without having possession of a shunting road.

Maintenance and Reliability.

The difficulty of access to both gas mains and electric cables in a busy yard is one of those important points of maintenance to which I have already referred in general terms. It is a strong point in favour of overhead wiring systems that they can be dealt with easily in case of breakdown, causing but little interference with traffic. The need for reliability is paramount in goods yard lighting. It militates against series running of electric lamps because of the necessity for the use of automatic cut-outs, with the chance of one not working and putting out a circuit. In the same way it points to the advisability of multiple burner gas lamps. To depend on a single mantle for the lighting of some vital spot in a yard would manifestly be bad practice, In general the primary aim is to avoid breakdowns by simplicity and good design in the installation, but the hardly less important secondary object is to secure that in the eventuality of a breakdown matters can be easily and speedily put right. Theoretical schemes of lighting will often have to be modified to accord with these principles.

ENGINE SHEDS.

Although not dealing at length with sheds of this class, I am treating them separately because they have one or two distinctive features. First there is the element of danger owing to moving engines and to the inspection or wash-out pits which are usually provided. This makes an adequate minimum illumination imperative, and I do not think it should fall below 0·05 foot-candle, at any rate not in the neighbourhood of the pits. Then engine shed lighting is a case where vertical illumination plays an important part, because the sides of engines standing in rows must be properly lighted to enable the cleaners to do their work effectively. This means that reflectors of an open pattern should be used. A further feature, fortunately peculiar to these sheds and their auxiliary buildings, is the accumulation of dirt and the corrosion of metal work due to a more or less permanently smoky atmosphere. This calls for fittings which can be easily cleaned, such as are provided by a good quality of vitreous enamel, and in electrically lighted sheds all-porcelain lamp-holders have been found very satisfactory in withstanding the corrosive effect of sulphurous fumes.

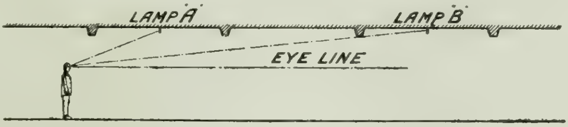


FIG. 7.—Showing illumination of subway by bare lamps screened from the eyes by transverse beams in the ceiling construction.

SUBWAYS, BOOKING OFFICES, ETC.

Requirements in Subway Lighting.

Uniformity is quite as important in subway lighting as it is on platforms, and all the measurements of illumination which I have made tend to show that the minimum illumination need not be high so long as a reasonable degree of uniformity is secured and, it should be added, an absence of glare. As it very frequently happens that glazed tiles line the walls, no elaborate reflectors are necessary, the somewhat despised conical opal shade being quite effective so long as it is deep enough to screen the lamps from the eyes. Unfortunately that enemy of good lighting, the advertisement contractor, often covers the white tiles with his dark posters, thus depriving the lighting engineer of one of his great assets. Fig. 7 indicates a special case of subway lighting where simply bare lamps on batten holders are used. Here the eye is sufficiently protected from glare by the beams supporting the roof, and diffusion is obtained by whitewashed walls and ceiling. It will be noticed that as the lamp at B comes into view the rays from A are just reaching such an angle above the eye-line as renders them harmless, and it is therefore impossible, in looking along the subway, to see more than one or two lamps out of the whole row. Fig. 8 is a view taken by artificial light of the subway in question.

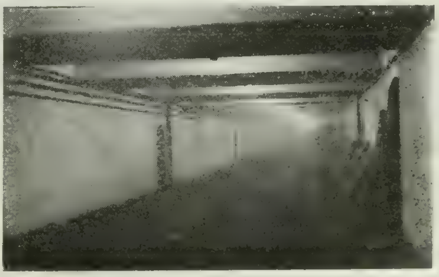


FIG. 8.—View of subway by artificial light, showing effect of placing lamps between beams on ceiling.

Mixture of Natural and Artificial Light.

It has always been a difficult problem to provide satisfactory illumination where daylight and artificial light are mixed. An example which is frequently met with on railways is the case of steps leading from a platform in daylight to a subway artificially lighted. The suggestion has been put forward to grade the illumination so that there is no sharp transition from one intensity to another widely different, but I am afraid the idea is hardly practicable in most cases owing to the very large variation in daylight between the extremes of bright sunshine and a dull cloudy sky. Personally I have never gone further than arranging for two systems of illumination, one set of lamps being in use during daylight hours and an additional set being switched in as daylight fails. This can hardly, perhaps, be called a solution of the problem, and I have mentioned it more particularly in the hope that discussion may bring forth some better plan. It is desirable that the minimum illumination on steps should not under any conditions fall below 0·25 foot-candle, and if the general surroundings are bright, it should be higher than this.

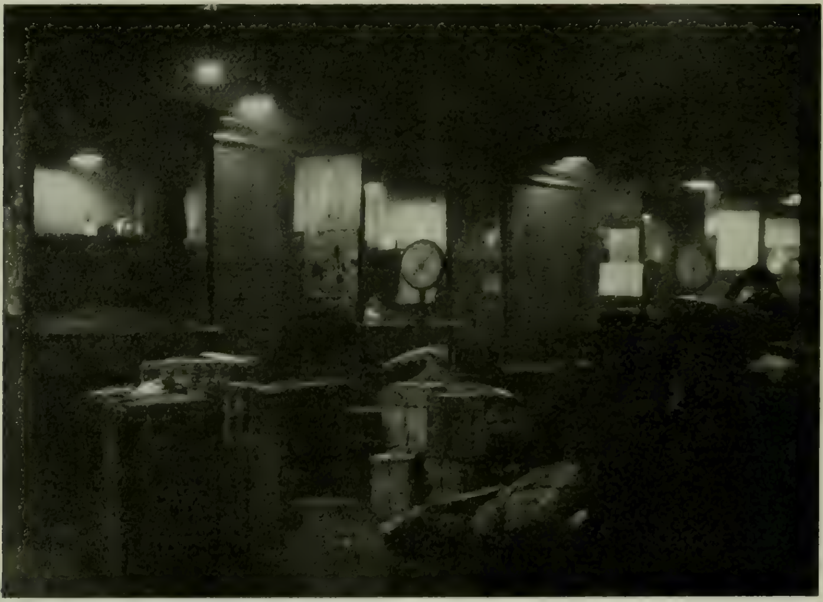


FIG. 9.—Showing methods of lighting scales, checking desks, etc., in parcels offices.

Skylights and Roof Cleaning.

The architect often seems to come in for criticism at the meetings of this Society, and he certainly cannot be let off when the present subject is under consideration. Why is it that booking-offices have in the past so frequently been planned with an utter disregard for lighting? It is not unusual to find the only window giving on to the platform at a point under low station roofing, so that nothing but borrowed light can ever enter the office. In several such cases it has fortunately been possible to construct a skylight, which has soon paid for itself by the amount of artificial light saved, apart from the greatly improved working conditions of the booking clerks. But it is obvious that skylights and glass roofs generally will soon lose their value if they are not kept clean, and insistence on regular cleaning might well be considered one of the many duties of a railway lighting engineer.

Booking Offices.

The lighting of offices in general does not come within the scope of this paper and was, moreover, fully dealt with at the last meeting of the Society, but there are one or two special features in the lighting of large booking offices at terminal stations which may be referred to. First of all the intensity of illumination should be above the average for offices, in view of the large amount of checking of ticket numbers that has to be done and the considerable sums of money handled. Then the fittings should be designed to give good vertical illumination on the ticket cases. This points to the use of angle reflectors where local lighting is in vogue, but it may be mentioned here that recent experiments with direct and semi-indirect lighting in a large booking office have shown that very satisfactory results can be obtained by the latter method. The number of necessary lighting points is greatly reduced under this system and a forest of pendant lamps can be replaced by one or two bowls. Apparently the vertical illumination thus obtained is sufficient for reading ticket numbers with ease, and the booking clerks show a decided preference for illumination without the glare which can never be entirely avoided by direct lighting. There is much to be said for careful design in the switching of booking office lights so as to allow for variations in working, according to which ticket windows happen to be in use, but our experience has been a warning not to carry this too far. A clerk is generally too busy or is disinclined to attend to the control of lighting even when switches are placed temptingly near at hand and money expended in the installation of an elaborate system of control is more often than not thrown away. A booking office at a terminal station is one of the few places, in my opinion, where special emergency lighting is justified. A serious breakdown would so completely dislocate the working and have such far-reaching effect that an alternative lighting system is desirable.

Parcels Offices.

No very special features present themselves in this class of lighting except the need for local illumination on scales, checking desks, etc., to supplement the general lighting of the open office where the parcels are dealt with. Fig. 9 is an example of such local lighting.

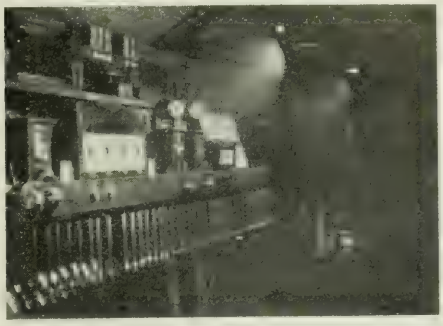


FIG. 10.—Showing gas burners in special reflectors used to direct light on to levers and instruments in a signal box.

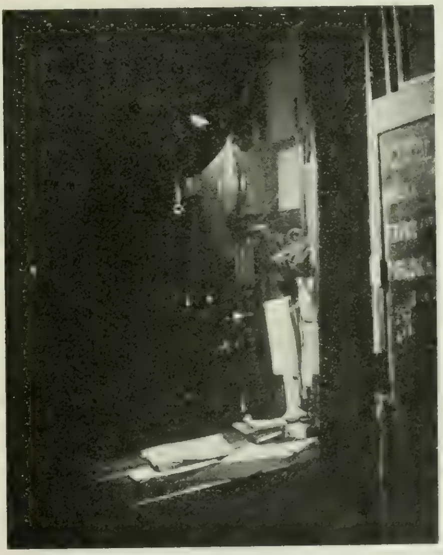


FIG. 11.—Showing similar unit used to illuminate desk and blackboard in the same signal office.

Signal Boxes.

Further examples of screened lighting are given in the above views of signal-box interiors. Figs. 10 and 11 show special reflectors attached to inverted gas burners, so as to throw the light on to the signal levers and instruments, etc., and at the same time to shield the eyes of the signalmen. With electric lighting by tungsten lamps, with conical opal shades, it has been found that by setting these at an angle a very much improved illumination is secured on the instruments and levers.

Prevention of Theft.

The increase in petty pilfering which has been noticed in many directions recently has raised new difficulties for the lighting engineer. Locking lamp-holders are not proof against the modern thief, who will even go so far as to unscrew an inverted burner from a wall bracket and break open padlocked lamp cases. Unless a change for the better takes place there will soon be a large demand for "thief-proof" burners and lamps.

CONCLUSION.

In conclusion may I point out that I have dealt very frankly with the practical difficulties as well as with the points of value in the various fittings, lamps, systems, etc., referred to, because open discussion seems to me the best road to progress. The experience recorded is, of course, that on one railway only. It is hoped that in the discussion, the experiences of others will be freely put forward.

I may finally recall some of the principal points to which reference has been made—points common to all illuminating engineering, but looked at in this paper from the standpoint of a *railway* lighting engineer. *First*, the need for a standard minimum of illumination in each class of lighting which shall ensure comfort for the passenger, efficient working conditions for the railwayman, and safety for both. *Secondly*, the need for simplicity in design both of installations as a whole and of details in fittings, to ensure reliability and to avoid costly maintenance. *Lastly*—and this has only been vaguely suggested in the paper—the need for attention to lighting at the very inception of all new schemes so that the best devices of illuminating engineering may not be introduced as an afterthought or omitted altogether, but may be as integral a part of the scheme as any of the constructive or decorative details.

I must acknowledge my indebtedness to Mr. Dow for kindly photographing the various examples of lighting given in the paper and to the Chief Engineer of the London & South Western Railway for permission to reproduce them.

DISCUSSION.

Mr. HAYDN T. HARRISON thought the paper had come at a very opportune moment. Before the war a great deal of attention was being given to railway lighting, but the war intervened and he was afraid that a great deal of valuable work would be lost. Fortunately, Mr. Cunnington had been carrying on that work and had now given them the benefit of his experience which would be of considerable value in the future. A year or two before the war he (the speaker) had been called in to advise as to the lighting of a large railway station which had been lighted for years on the old haphazard methods. The interesting point was that the directors did not so much want to reduce the cost as to improve the illumination. Previously, the illumination had been below 0·15 foot-candle. It was proved that the station could be lighted by four different modern methods of illumination, three of which gave a minimum of 1 foot-candle for the same cost as previously.

Mr. Cunnington had been very kind in his remarks upon his (the speaker's) paper of 1912. At that time the ordinary illuminating engineer, who was not a railway engineer, had a difficult problem to tackle because in railway lighting nobody knew as well as a railway engineer what the requirements were, and it was not easy for them to define them. The members of this Society would agree that as part of the general public they knew the requirements in the matter of illumination for the parts of railway stations frequented by the public. For instance, he was at one of the London termini the other day, which was lighted by relatively small units at a low altitude and considerable distance. One of these units had gone out and in the usual rush for the train he himself nearly stumbled over a bag on the platform. Immediately afterwards a very old man fell over it and had to be carried away seriously injured. That demonstrated that the illumination was not enough. It was at one time considered the duty of the State to look after the safety of the public and that was why in his own paper of 1912 he said that he looked forward to the time when for the illumination of roads and public places they would, as a Society, be able to say that nothing below a certain point would be safe. Mr. Cunnington helped that idea forward, for although he did not agree with the minimum which he (Mr. Harrison) had suggested, viz., 0·25 foot-candle, yet he suggested a useful minimum of 0·15 foot-candle for certain classes of stations and he also emphasised the point that the safety of the public must be considered.

Attention was called in the paper to dispensing with the outer globe when using half-watt lamps. He had found exactly the same thing in public lighting, viz., that the outer globe could be dispensed with, and that was important at the present time, having regard to the difficulty of getting good glass and the high price which had to be paid for it. The question of whether the outer globe could be dispensed with from the point of view of glare, however, was another matter. In railway stations where everybody was supposed to keep their eyes below the level suggested by the diagram, the difficulty was theoretically got over, but if there was not a very deep reflector over the lamp, such as was shown in Fig. 2 (p. 61), they were liable to get the image of the filament, with its high intrinsic brilliancy, against some dark sky-line, which was the worst form of glare. Therefore, he assumed that the author meant that the outer globe should only be done away with when a deep reflector was used. The difficulty of the main fuse melting when high voltage lamps burnt out could best be got over by fusing each individual lamp.

He was glad the author laid stress on the illumination ratio, *i.e.*, the ratio of minimum to maximum illumination. Personally, he had always held the view that the nearer it was possible to get to even illumination the better, although there were a great number of people who thought otherwise and who would prefer to walk from a poor to a good illumination in order to see, rather than have a lower degree of illumination which was approximately the same everywhere. As regards the height at which illumination should be measured, he had always been in favour of the usual metre or 3 feet distance for convenience sake, but since the accident to which he had referred he was not at all sure that the measurements should not be taken on the platform level or reduced to that level by calculation. He was also glad to see the author had brought out the important question of measuring the vertical illumination. That was just as important for a great number of reasons—and in some cases a great deal more important—than the horizontal, and for that reason it was difficult to lay down any specification for conditions where high sided trucks were in use, such as had been mentioned in the paper. The example of 1,000 square yards which Mr. Cunnington referred to, using a 200 candlepower lamp would give an illumination of less than 0·01 foot-candle as a minimum, if the lamp was put at the end of the space of 50 yards by 20 yards. Moving that much depends on the width of the area.

The author seemed to think there was a limit to the amount of illumination that should be used, and his first paragraph rather tended to show that we had been largely concerned in putting forward ideals, but he would remind the author that many of what were regarded as ideals would now be regarded as necessities, which process, he hoped, would continue as it would tend to brighten the lives of all.

Mr. J. H. **Haigh** (Lancashire and Yorkshire Railway Co.) said that he had found many helpful suggestions in Mr. Cunnington's paper, but that one of the particular difficulties of the railway lighting engineer was that he so often had to make the best of a bad job. The areas and buildings that required lighting were many and various, and the schemes of the engineers and architects did not in many cases allow the lighting engineer to approach the ideal. He suggested that the lighting engineer should be called in earlier and given a freer hand because the more nearly the lighting approached perfection the better would the railway staff be able to carry out their duties.

The question of standardisation was well worth study because the smaller the number of sizes and types of lamps the more economical and efficient the maintenance. On the Lancashire and Yorkshire Railway the medium inverted mantle was found to be most economical from all points of view, although the vertical mantle in some cases gave a better distribution of light. Present day glassware gave much trouble, particularly with vertical burners. The sample small power lamp for close spacing was most interesting, but it should be kept as small as possible consistent with maximum efficiency, so as not to be a conspicuous object.

Station name plates were difficult objects to light, and he looked forward to the time when three or four at intervals along the platform would be fixed at right angles to the edge. Such name plates could be illuminated by the same lamps that sufficed for general illumination.

Mercury seals mentioned by the author were not particularly efficient as it was found that air somehow got into the pipes in almost every case when lamps were extinguished for a time. A suggested remedy for this was to allow a small leakage to ensure gas being right up to the seal, but Mr. Haigh felt sure that no lighting engineer would approve such a method.

Marshalling sidings, he thought, should have general lighting over the whole area independently of that at the points and crossings, his experience being that such lighting improved the working of the sidings and tended to check pilfering. The minimum value, however, might safely be as low as 0·002 to 0·004 foot-candles, because wagons standing in rows would, at some point, be much more visible by reason of being nearer to the point of light, and the shunter's eye would be guided naturally to the end wagon.

The difficulty of lighting a subway, so as to avoid the sudden transition from daylight to the subdued brightness below, might, Mr. Haigh thought, be got over by grading the tiled sides, the tiles at the bottom of the incline being brighter than those at the top. A partial solution of such a difficulty could be seen at Victoria Station, Manchester, where the upper end of the incline was lined with enlarged photographs of places of interest.

Mr. Haigh would be glad of any information on the maintenance of incandescent gas lighting, *i.e.*, the number of burners under one man's supervision, the intervals between visits, the system of maintenance between the visits of the regular attendant, and whether such attendant cleaned the whole of the glass in the lamps.

Mr. A. H. **Stevens** (London and North-Western Railway) said that it would be interesting to have fuller particulars of the cost of maintenance of electric lighting, and especially of the savings that might be brought about by using smaller units. He would also like to know the distance which the bulb of a half-watt lamp was intended to project below the reflector, *i.e.*, how much of the lamp was exposed to the weather.

Mr. P. **Whysall** (Underground Electric Railways, Ltd.) said there was no doubt that good station lighting paid. It reduced considerably the number of accidents and inconveniences met with in bad lighted areas. By good lighting, however, he meant well designed lighting, which was not a matter of providing a certain illumination in foot-candles only, but also depended upon the proper selection and arrangement of lamps and fittings. He thought that it would be generally agreed that the lighting of many railways left much to be desired, but he excluded from this statement main line termini and stations on the underground railways. The average suburban station was insufficiently lighted and presented a gloomy appearance, and the figures presented in the paper seemed to confirm this view. Thus, in the author's classification, there was only one station in the first class, nine in the second class and twelve in the third class. The first class station, all would agree, was satisfactorily lighted, and two out of those grouped in the second class might almost be ranked with it. The average given for the second class, 0·25 foot-candles, should, he thought, be regarded as the absolute minimum; 66 per cent., however (*i.e.*, six stations), were below that minimum. The diversity factors also seemed to be very high in some cases. In the third class stations the conditions were much below even those referred to above.

The curve presented by the author revealed considerable progress in railway carriage lighting. He hardly thought that a similar curve for platform lighting would give equally good results. He held the opinion that they should aim at using as large units as possible, and adjust the spacing to get uniform illumination. He was glad to see the photograph illustrating the method of concealing lamps between horizontal beams in the ceiling of a corridor. The arrangements for lighting such passages depended on the construction of the roof, but the effect of a long line of exposed lamps was objectionable; on the other hand, if opaque reflectors were used, the ceiling was apt to be unduly dark. On the underground railways he had found that spacing of the kind described by the author was helpful in enabling drivers of trains to see the signals more easily.

The question of the plane at which measurements of illumination should be made required to be settled, as at present measurements were made at various heights, and this led to confusion. He was inclined to think that measurements should be made at the platform level, as facility to read newspapers was of secondary importance; this at least was true on the underground railways, although on the main lines, when the intervals between trains were longer, matters might be different. The accident mentioned by Mr. Harrison might have been due, not to inadequate lighting, but to people crowding together.

He was glad to see that the author had been experimenting in the lighting of name-plates for stations. He thought that distinctive and well lighted name-plates should now be regarded as essential. This point had received special attention on the underground railways and was much appreciated by passengers. As to the life of lamps, he was surprised at the life of 10,000 hours, apparently obtained with only a small reduction in voltage, as he could not get such results even with 10 per cent. under-running. He would like to know the types of lamps to which this applied.

Mr. H. PERKIN (Great Central Railway) referred to the importance of adequate maintenance of lighting installations. He thought that railway companies should have special staffs allotted to this work. In the case of gas lighting there was at present divided control, in one case the traffic department being responsible for mantles, and the engineer's department for the cleaning of burners. Another point on which information was needed was the influence of the material of which platforms were composed, *i.e.*, as regards colour and reflection of light. It would, for example, be interesting to know whether ashes or broken slag was preferable from the lighting standpoint.

Mr. F. W. GOODENOUGH agreed that the paper had come at a most opportune time and was full of valuable material. He thought too much importance could be attached to the question of the ratio of the maximum to minimum lighting, provided the minimum was sufficiently high. The whole point was not to have any badly lighted patches. If every part was fully lighted it did not matter nearly so much if the maximum was a considerably higher ratio than the minimum. To take an extreme case, daylight, it was possible to have very marked differences between the minimum and maximum illumination in a street without the slightest disadvantage, supposing the whole street was adequately lighted. There might be a ratio of 10 to 1 on a well lighted platform but the eye would not observe it in the least. In pre-war days, when Whitehall was one of the best lighted streets in Europe, it was possible to motor down that thoroughfare at 25 miles an hour and see the whole length of the roadway clearly in front without any observation by the eye that there was any difference in the maximum and minimum illumination, which, as a matter of fact, was about 12 to 1. The trouble arose if there was a bad patch.

He was rather surprised at the author putting the damper on railway companies spending more money on station illumination at present. He did not think, from his observation, that we had got anywhere near the point of extravagant lighting in even the best lighted terminal stations in London. One of the speakers had excluded terminal stations from any criticism in regard to lighting, but he personally still thought that improvement could be effected in the approaches to many of the terminal stations, that is, at the alighting points and in the drive in. There was also still very inadequate lighting of the portions of the stations where cabs drew up and loaded up on the arrival platforms. After all, the whole object of lighting stations was to enable operations to be carried on in an expeditious and efficient manner, without accident and without loss of time, and there were not many railway stations where the lighting at night was sufficient to enable one to move about as rapidly as was possible in the day-time. That was the criterion that should be applied.

The author had referred to architects ignoring the lighting requirements, and other speakers had referred to the lighting engineer being called in too late. Frankly, from the appearance of some railway stations it would not appear that an architect was ever consulted. Many railway stations looked as if they were not planned by anyone who would call himself an architect.

With regard to mercury seals, he had had something like 10 years' experience of the use of these in the lighting of alternate lamps at Victoria Station and no difficulty had been experienced with their working. With regard to the measurement of vertical as well as horizontal illumination, it seemed to him that if they got the horizontal illumination sufficient, they were bound to get the vertical illumination right. They could not get light down from the horizontal plane without illuminating the vertical planes between, and he did not think it was necessary to measure the lighting both ways. In conclusion, he emphasised the conclusion that we had reached a sufficiently high level in railway lighting to say that we had got to a point when no more money should be spent.

Mr. A. **Wise** said that the Society was to be congratulated on the excellence of Mr. Cunnington's paper and the large amount of useful data contained therein. Mr. Cunnington had suggested that gas-filled lamps were unaffected by weather. From the standpoint of life and efficiency such lamps were not adversely affected, but they should not be used without any protective device at all. Thus if water (such as rain or condensed moisture) was allowed to impinge on the bulb of the lamp when glowing, the temperature of the bulb (at any rate of the higher wattage lamps) would cause it to crack. The question of dirt and dust, which could not be eliminated from railways, was an important consideration, which made the removal of protecting glasses desirable, but this could only be done when the reflector was designed on the lines of the two examples cited in Fig. 2.

The subject of series burning of gas-filled lamps had been absorbing the attention of lamp manufacturers for some time, and the conclusion arrived at was that this system was to be deprecated. Its introduction was the result, first of the expense and trouble of re-wiring existing series arc lamp circuits, for which these gas-filled lamps were substituted; secondly, of the fact that gas-filled lamps were primarily only available for higher currents, and the lower voltages enabled lower candle-power lamps to be installed. The latter drawback had been overcome to some extent and high voltage lamps are now made for comparatively low candle-powers.

The phenomenon mentioned by Mr. Cunnington in connection with the failure of gas-filled lamps may be explained as follows. Series burning circuits were usually fitted with an automatic cut-out and substitutional resistance, so that in the event of one lamp of a series failing it was automatically cut out of circuit and the continuity of the voltage maintained. With high voltage parallel burning lamps the failure of the filament suddenly placed the full voltage of the mains across the leading in wires, and this might result in the formation of an arc between them which eventually short-circuited the mains and blowed the fuse.

Another phenomenon in high voltage lamps was known as "flashing." The origin of this had not yet been definitely determined, and although it could be reproduced artificially it could not be entirely eliminated owing to its intermittency and recurrence under varying conditions. Fortunately the effect only occurred very infrequently, and should therefore not deter the use of high voltage gas-filled lamps with their inherent advantages over the series system.

Mr. H. E. ROBARTS (South Eastern and Chatham Rly.) agreed with Mr. Whysall's remarks as to the fixing of lamps between the horizontal beams of station roofs. One of the reasons for putting lamps on the horizontal beams so often in the past was possibly that the beams offered a convenient fixing for the lamps.

As regards the lighting of goods yards, the concentration of lighting on points and crossings was most important. General illumination of a shunting yard, so as to obviate the use of hand lamps, could not generally be provided satisfactorily. In the majority of yards the sidings were so close together that the shadows cast by the wagons made general lighting very difficult.

The PRESIDENT, in bringing the discussion to a close, said the subject was a very interesting one because it dealt with electric and gas lighting, acetylene and all sorts of other curious kinds of lighting which he did not disparage at all, but which might usefully be employed in certain cases. Therefore, this was one of those subjects upon which they could all meet on common ground. He would have liked to have heard more of the luxurious cases of high pressure gas used on the Brighton line, for instance, because such examples of high-class lighting as that of Whitehall made the other man sit up and see if he could do as well. He rather quarrelled with the expression "vertical illumination." He had not got a better one to offer, but when they spoke of horizontal illumination they meant illumination in the horizontal plane and when they spoke of vertical illumination they meant illumination in the vertical plane, and the expression "vertical illumination" was rather contradictory because the light was not vertical. He thought somebody might find a better word than this. Some of the photographs had been very interesting, and the lighting of the signal boxes he thought was extremely good; it rather confirmed him in the heretical views he had expressed at a previous meeting.

Mr. L. GASTER, in briefly congratulating the author on his paper, recalled that Mr. Cunnington had worked under him on illuminating engineering previous to his taking up his position on the London and South Western Railway. He thought that this company was to be congratulated on appointing a special lighting engineer to deal with all illuminants. The comprehensive data presented in Mr. Cunnington's paper would serve as a useful basis for further work, and if similar information for all the chief railways could be assembled on a uniform basis this would enable definite standards of illumination to be evolved.

Mr. H. I. BOND (London and South-Western Railway) (*communicated*) :—

Mr. Cunnington is to be congratulated on the concise way in which he has dealt with an extensive subject. Further, the restrictions of lighting that have been, and are still obtaining, have made his task of treating the matter in a normal manner more difficult. Having been responsible up to quite recently for the policy adopted and the method of carrying out the work which has formed the basis of the paper, I do not propose to make any comment upon it, but I welcome the opportunity given me for emphasising what appears to me to be some of the more important points.

The cost of maintenance is, rightly, given due prominence in the paper. In all lighting installations it is an important matter but especially so to a railway company which has its lighting plant spread over a very wide stretch of country with its attendant difficulties of control. Closely linked with maintenance is the question of standardisation of fittings so that the maintenance man when travelling should require as few as possible. Another feature of standardisation relating to supply companies requires attention. It would be of material assistance if electrical supply pressure could be made much more uniform, if the quality and pressure of gas supplied by various companies throughout the country could be more completely standardised.

The importance of oil lighting to a railway is also very great. About 50 per cent. of the railway stations in this country are illuminated with this commodity, while in addition it is used largely for signal lighting and for hand lamps. Uniform lighting in the principal part of a station is very necessary, and the contention that if this condition prevails it need not be high, is undoubtedly true. But in less important parts of the station uniformity could only be obtained at a cost that would not be justified. Lights provided for a special purpose can always be used if thought advisable. By these methods a high maximum illumination is rendered unnecessary.

Mr. N. W. PRANGNELL (*communicated*): I observe that in Fig. 1 Mr. Cunnington indicated about 1·9 foot-candles as the present illumination in railway carriages, while, further on in the paper, he suggests 0·5 foot-candles for platform lighting. I should like to ask whether he has considered the importance of the relation between the illuminations in these two cases. In his paper he recognises the importance of guarding against glare. Now a person standing on the platform, when opening a carriage door to enter a train, faces an illumination of at least five times that prevailing outside. I would suggest that the platform illumination should bear a much closer relation to that provided in the carriage and am disposed to think that the incident mentioned by Mr. Harrison—the man falling over a bag—might have been due to his having been dazzled by the lights inside the arriving train. No doubt it would mean a great increase in cost to provide an illumination on the platform as high as that in the train, but possibly this extra cost might be diminished if additional platform illumination could be switched on from the signal box, in conjunction with the operation of the signals, when a train arrived.

I should like to add my thanks, both as a member of the Society and the general public, to Mr. Cunnington for his very able paper.

Mr. E. S. D. MOORE (London and North Western Railway) (*communicated*):—

I listened with great interest to Mr. Cunnington's able paper and gladly take advantage of the invitation extended at the meeting to communicate some remarks to the discussion. These are conveniently arranged under headings as follows:—

Maintenance and Standardisation.

I agree with Mr. Cunnington's remarks on these subjects. A difficulty, however, arises in connection with the standardisation of gas burners, owing to the varying conditions met with on a large railway system, *e.g.*, as regards calorific value, specific gravity, composition and pressure. On our own railway we have to deal with calorific values ranging from 400 to 600 B.T.U. per cubic foot. A pressure of 20-10ths is the minimum necessary for successful inverted burner lighting. We have also given considerable attention to the adjustment of burners to suit qualities of gas. We have accepted the principle that a particular burner should give substantially the same value at any point on the system. Thus, the burner employing the Bijou mantle is rated at 30 candlepower, the burner using the medium, or No. 2 mantle, 50 candlepower, and so on. This ensures uniformity of illumination under standardised conditions. We have also adopted a burner which, so far as its general design is concerned, is capable of dealing satisfactorily with practically the whole range of calorific values mentioned above. The only alteration needed in order to adjust the burner to the prevailing quality of gas is to vary the diameter of the nipple orifice. We use the fixed nipple, working at constant pressure, with a view to securing economy in operation and efficiency. In order to arrive at the sizes of nipple required for any particular place, we obtain a sample of the gas and test this with a range of standard nipples, and the size giving the standard candlepower with the highest efficiency is adopted throughout the installation. There is another point of considerable importance, viz., standardisation of mantles. It is of little use taking considerable trouble in the adjustment of the burner unless the flame correctly fits the mantle. The dimensions of the same type of mantle made by different manufacturers may vary very considerably, and we have found it necessary to limit the variations above and below a standard figure settled by careful experiment.

Dispensing with Globes.

Our experience on the above point coincides exactly with Mr. Cunnington's. We are successfully employing large half-watt units with about half the bulb of the lamps exposed to the weather. Where the glare of the filament would be objectionable we use tip-frosted lamps. We have also had successful results both as regards maintenance and illumination with gas burners in Holophane open type reflectors, but without inner globe.

Standards of Illumination.

I agree that it is desirable to adopt a standard which should be adhered to as far as possible. There are, however, difficulties. These are, I think, reflected in the figures given in regard to Class 2 Stations in Table 1 of Mr. Cunnington's paper, where variations above and below the suggested figure of 0·25 foot-candles, of 140 per cent. and 64 per cent. respectively are to be noted. Uniformity of illumination is undoubtedly desirable and allows a lower average illumination being provided, but the commercial aspect of a low diversity factor, especially with gas lighting, has to be considered, since both first cost and maintenance are involved. A standard height of measurement is most desirable and the height suggested by Mr. Cunnington (3 feet) is undoubtedly an important plane. Illumination at platform level is, however, also important. It appears, therefore, that the only way out of the difficulty is to take readings at both levels.

Circular Name-plates.

We have found that this type of name-plate when fixed rigidly to reflectors offers considerable wind resistance, with consequent strain on cup and ball joints, etc. We are now experimenting with a non-rigid clip with, up to the present, satisfactory results.

Petrol, Air Gas, etc.

We have both engine-driven and weight-driven plants in use on this system, and find that the latter type is considerably more economical in petrol consumption, costs less to maintain and is more reliable. It is most important to use mains and services of ample capacity in order to secure good results and freedom from condensation.

Lighting of Roofs.

From a strictly economical point of view, upward illumination represents waste, yet the gloomy effect produced by leaving high station roofs in total darkness discredits the platform lighting, as it tends to give the impression, owing to the strong contrasts, that the latter is worse than it actually is. Reflected light from walls, etc., of buildings cannot always be relied upon. Flame arc lamps have proved successful for stations of this type, which are, however, fortunately becoming less usual.

Goods Shed Lighting.

A much higher standard of illumination for these premises, as compared with station lighting, is necessary, and the figures suggested for Clause 1, at any rate, are satisfactory. The frequent use of whitewash on the walls and columns, etc., of these and other premises is a great aid to illumination.

Yard Lighting.

I agree with Mr. Cunnington's remarks under this heading, and after experience of both methods, consider that the employment of comparatively small units of, say, 200 to 250 candlepower at a height of approximately 16 feet above the ground at most important points is the best method of dealing with this problem. The suggested standard of vertical illumination is interesting and well worth following up.

Engine Shed Lighting.

The figure of minimum illumination suggested by Mr. Cunnington seems well on the low side, and it is our practice to give a minimum roughly three times this value.

Signal Box Lighting.

The descriptions and illustrations of the methods described are interesting, but the contrasts which would be produced by shading the lamps to the extent shown would have rather a depressing effect. We have dealt with the problem by fixing lamps in deep shades located well up in the roof and slightly towards the back of the box. This secures a well-diffused illumination for the whole of the box, without glare.

Mr. MARCUS MACDONALD (Great Western Railway) (*communicated*) :—

The method of using large gas-filled lamps without outer globes, described by Mr. Cunnington, doubtless occasions a saving in the cost of glassware (especially at the present high prices), but might not this advantage be compensated by increased cost of lamp renewals ? Many operations on railways take place in an atmosphere of sulphurous smoke from engines, making frequent cleaning necessary. In my experience, when outer globes are dispensed with, the cleaning has led to a considerable loss of lamps (of the ordinary vacuum type) through rough handling. With outer globes this would not be so liable to occur.

A point of importance is the future of arc lamps for station lighting. The costs of maintenance and attendance constitute a drawback, and I should like to know the extent of the saving that can be made in this respect by substituting incandescent lamps. From Mr. Cunnington's paper it would appear that the figure for lamp renewals with gas-filled lamps is not high, but the life mentioned, 10,000 hours, even with 2—3 per cent. under-running, seems amazing. I should like to know the average life under working conditions, when lamps are respectively run on full voltage and with 2—3 per cent. underrunning. Information on the nature of the rearrangements in converting from arc lamps to glow lamps (*e.g.*, as regards decrease in height of suspension, and the equivalent in gas-filled lamps of a 10 ampere flame arc lamp) would also be useful.

In theory the great value of adequate switching arrangements, as a means of economy, is evident, but the saving depends in practice on the human element. In one large station it has been found judicious to employ an old servant of the Company to do nothing else but walk round and turn off lamps which are not needed.

I should be glad to know if the 3 ft. level of measurement may now be considered standard practice, as much photometry in railway stations was formerly done at 4 ft.

Mr. CUNNINGTON, in reply :

The accident referred to by Mr. Harrison has been quoted as showing that illumination should be measured at platform level. This, however, does not seem necessary if the minimum illumination suggested at 3 feet is fairly high. This value for Class III. stations is low, and a still lower value at platform level might be highly undesirable. In such cases it therefore seems advisable to supplement readings at 3 feet by readings on the platform ; but in general 3 feet is a useful working level because there are many things to be considered as well as reading newspapers, *e.g.*, the carriage door handles and labels on luggage. Quite a number of speakers made reference to this matter. There seems a consensus of opinion in favour of 3 feet so long as measurements are also made at platform level when the illumination is low. I would suggest that whenever the illumination at 3 feet is less than 0·05 foot-candle a supplementary test should be made at platform level. Perhaps I may also draw attention to the difficulty of measuring low horizontal illumination, such as 0·002 foot-candle mentioned by Mr. Haigh, and I would point out in answer to Mr. Goodenough that that is one of my chief reasons for suggesting a vertical instead of a horizontal plane for goods yard measurements. I am sorry that I have erred in speaking of "vertical illumination," but can only plead that Mr. Trotter has himself set the example by the use of the analogous term "horizontal illumination." I cannot suggest an alternative which would be equally simple and self-explanatory. Furthermore, while the *light* is not, as Mr. Trotter says, vertical, I think the *illumination* is.

Mr. Whysall has expressed the view that the order of illumination indicated in the classifications of stations is unduly low. True, there is only one station in Class I.—merely because only one station of the large terminal type exists on the line; this would apply to many other railways. The value of 0·25 foot-candles put forward is really fairly generous since, if taken literally, it means this value of illumination even in the dark corners. People sometimes underestimate the conditions of lighting which a minimum of 0·25 foot-candles implies. Actual tests would probably show that many very well lighted stations only just comply with this requirement (in fact I believe this would be the case on many of the Underground stations). It must also be remembered that, although the war is over, there are still restrictions in lighting which compel economy. The conditions of illumination in Class III. are naturally low, for lighting must bear some relation to traffic. An Underground station, with its millions of passengers, cannot be compared with (say) a wayside station in the wilds of Dartmoor, where any passenger not known to the stationmaster would be regarded as an object of interest. Mr. Goodenough, too, has set rather a high ideal when he says that lighting at night "should enable one to move about as rapidly as in the daytime." Surely even Whitehall, well-lighted as it is, would hardly reach that standard!

In regard to the classification of stations and the recommended minimum values of illumination, both Mr. Whysall and Mr. Moore point out that there are several stations in Class II. in the table which fall below the proposed minimum of 0·25 foot-candle. I should mention that the measurements given in the table were taken at random from a collection of data, some of which were obtained five or six years ago, and that the number of stations in each class is purely a matter of the tests available. The intention was simply to demonstrate the reasonableness of the minimum arrived at by averaging the stations. It was inevitable that at some stations improvements would be necessary in order to bring them up to the standard. If the minimum illumination of 0·25 foot-candle for stations of Class II. and the height at which measurements are made can now be taken as agreed, the writing of this paper will at any rate have marked a slight step forward in the matter of railway illumination.

I consider that uniformity is most important from the point of view of economy. Mr. Goodenough suggested that if the minimum was right it did not matter about the illumination ratio, but I do not agree, because if the minimum is correct it is not necessary to go extravagantly beyond the minimum and have a maximum (say) 20 times the minimum. The remarkable thing about the installation represented in Fig. 3 is that the illumination never reached more than 0·8 or 0·9 foot-candle, and yet it is a most usefully lighted station. It is the uniformity which makes it so satisfactory, and the economy is considerable.

Mr. Prangnell, in referring to the contrast between carriage and platform lighting, raises a point of some importance. However, a much greater contrast than 5 to 1 may exist before any noticeable glare occurs, besides which there is a certain amount of natural grading due to the stray light just outside the compartment. This contrast is, nevertheless, a real difficulty in stations corresponding to Class III. where the ratio may be as much as 100 to 1. Unfortunately it is just at such stations that Mr. Prangnell's suggestion for switching in additional light is not feasible.

The minimum of 0·15 foot-candle as given for engine sheds I take to be the figure obtained midway between two lamps under the most favourable conditions. I can hardly believe that dark corners of the sheds never fall below this standard. I had such dark corners in mind when I suggested 0·05 foot-candles as an *absolute* minimum. The figure of 200 candlepower for a space of 1,000 square yards was only approximate; in the extreme case taken by Mr. Harrison it would not give the minimum of 0·01 foot-candle, but it was only fair to allow for the lamp shining both ways. Less candlepower would give that minimum illumination in a normally shaped yard.

Mr. Haigh's suggested arrangement of name-boards fixed transversely seems a good one, but I should prefer local illumination for such boards rather than reliance on the general lighting which, if economically designed, would not be of a high order on a vertical plane fairly high up.

Mr. Haigh and Mr. Perkin both referred to maintenance of gas lighting. It may be of interest to mention that a scheme of complete maintenance by the engineer's department has been adopted in one district. In this case mantling as well as cleaning of burners is undertaken, and even the cleaning of globes in modern inverted lamps is not left to the traffic department. A few mantles are held by the stationmaster for cases of emergency. One man deals with about 1,500 burners, which he visits on the average fortnightly; the district however is a very compact one so that about 100 to 150 burners can be dealt with in one day. These figures are of course only approximate.

With regard to maintenance staffs mentioned by Mr. Perkin, the South Western Company has them in some districts. Maintenance is undoubtedly a most important matter; the gas companies knew it well enough, and the railway companies are finding it out. Good maintenance and uniformity of illumination in fact might be taken as the keynotes of the paper.

In reply to Mr. Stevens' request for information regarding maintenance of electric lighting, more particularly in reference to the scheme shown in Fig. 3, I may say that the reduction in cost was approximately 20 per cent. in maintenance and, as is noted in the figure, well over 50 per cent. in current. The vagaries of the illumination under the tungsten lamps in Fig. 3 are due to the variations in candlepower of individual 60-watt lamps. An average figure of maintenance cost before the war was 0·4d. per unit of current used.

In reply to Mr. Macdonald's query as to renewals of lamps when outer globes are dispensed with, I have not found the cost to be increased, but this may be due to the fact that the lamps themselves are not cleaned the cleaning being confined to reflectors. No doubt the loss of light through a dirty lamp is considerable, but not as great as through an outer globe which offers more surface to catch dirt.

I fear I have somewhat misled Mr. Macdonald, Mr. Whysall, and possibly others in regard to the under-running of gas-filled tungsten lamps. When I referred to 1 or 2 per cent. under-running I intended that as an indication of what might be *permanent* practice, but to secure the 10,000 hours' life it has been necessary to under-run as much as 5 per cent., and I am not sure whether this could be justified otherwise than as a war-time expedient. The best results have been obtained with 50-volt lamps (of the early type before Dutch importations), connected to the secondary of a transformer with the winding arranged to give about 47·5 volts. I have no figures available of average life under conditions other than the above.

Mr. Haigh has referred to the lighting engineer being called in too late. I am glad that point has been emphasised. In a recent case that came under my notice it was only found out by chance that some sidings were being laid down without any provision for lighting—but fortunately in time to arrange for a wider space to be left between certain of the roads so that lamps could be installed. Mr. Goodenough has replied to the point raised by Mr. Haigh as to mercury seals. It has also been my experience that they do not give trouble.

Mr. Stevens has asked as to the extent to which the half-watt lamp was exposed. I may say that this was fairly accurately shown in Fig. 2, which was drawn to scale. I have not used reflectors without outer globes except where they were fairly high up, or not of very great intrinsic brilliancy, so that the question

INDEX, March, 1919.

PAGE
British Scientific Products Exhibition (1919), The 88
Editorial. By L. Gaster 53

Illuminating Engineering Society—
(Founded in London, 1909).

Account of Meeting on February 25th, 1919 57
List of New Members 57
"**Some Notes on Railway Lighting and its Maintenance.**" By **A. Cunnington** (Lighting Engineer to the London and South Western Railway) 59
Discussion :—Mr. Haydn T. Harrison—Mr. J. H. Haigh (Lancashire and Yorkshire Railway)—Mr. A. H. Stevens (L. and N.W. Railway)—Mr. P. Whysall (Underground Electric Railways, Ltd.)—Mr. H. Perkin (Great Central Railway)—Mr. F. W. Goodenough—Mr. A. Wise—Mr. H. F. Robarts (S.E. and C. Railway)—The President (Mr. A. P. Trotter)—Mr. L. Gaster—Mr. H. I. Bond (L. and S.W. Railway)—Mr. N. W. Prangnell—Mr. E. S. D. Moore (L. and N.W. Railway)—Mr. M. Macdonald (Great Western Railway)—Mr. A. Cunnington (*in reply*)—Mr. C. R. Williams .. .. ..76—87
Trade Notes 88

---

of glare from horizontal light coming to the eye does not arise. In parallel running of gas-filled lamps, a fuse has been put in for every lamp, which appeared to be the only remedy at high voltage when lamps were liable to arc on fusing. I must thank Mr. Wise for his information in regard to gas-filled lamps, but his explanation of the failures does not quite cover all the cases I have met with, as the phenomenon mentioned also occurs when no cut-outs are in use. I am glad to note that Mr. Robarts confirms from practical experience my remarks as to goods yard lighting.

I am grateful to Mr. Bond for summing up in a few words the essential points dealt with. I should also like to acknowledge here the keen interest he has always taken in the photometric testing and planning of installations which provided the material for much of the paper.

Mr. Moore's most useful contribution to the discussion deals with a number of important matters. In many respects his experience coincides with mine. In particular he gives some useful information on the standardisation of gases and gas burners. It is interesting to know that total darkness above has been found to discredit platform lighting. One would imagine that strong contrast would have the reverse effect. The method described by Mr. Moore of lighting signal boxes seems good as far as avoiding glare is concerned, but fixing lamps well up in the roof is presumably not economical.

I was very glad to have the opportunity of reading a paper before this Society, especially as I feel myself, so to speak, a disciple of Mr. Gaster, and I appreciate the honour of thus participating in the celebration of the tenth anniversary of the Society.

Received later :—

Mr. C. R. Williams (*communicated*) : Having retired from the railway service, I do not feel justified in joining the discussion from a technical or official standpoint, but as an ordinary user of railways, whose past experience is such as to modify criticism with a consideration for the difficulties to be faced in railway lighting.

Railway history in Great Britain is replete with instances of the bad old system of watertight compartments and many of the difficulties above named are due to lack of co-ordination between departments, not only of any one railway company, but of associated companies using each other's stations and rolling stock. The result of this is apparent in the dissimilar methods of illumination provided at stations and in the trains of different railway companies.

It is to be hoped that with the closer association of the various railways under one executive committee, to say nothing of possible nationalisation, some standard may be arrived at for the effective illumination of premises and vehicles throughout the country and that proper diffusion of light be attempted in the rolling stock, with avoidance of glare.

As regards the illumination of passenger stations, Table I. in Mr. Cunnington's paper is interesting from the lighting engineer's point of view. Writing, however, as a mere passenger, whose fate is to change and consequently wait at various stations after dark, I would say that, in my opinion, the general effect of the gas lamps at Southampton West is far better and more cheerful than that of the partially obscured electric filament lamps at Salisbury. Oil lighting being such a large item in annual costs of railway operation, it is interesting to know that trials of pilot flame lamps have been successful. Some years ago I made some trials without being encouraged to go further; much depends upon the staff.

Generally, efficiency and economy are best secured by adopting a judicious middle course between standardisation and the too prompt adoption of improvements when available.

BRITISH SCIENTIFIC PRODUCTS EXHIBITION, 1919.

The King has graciously consented to act as Patron of the British Scientific Products Exhibition, 1919, which will be held at the Central Hall, Westminster, from July 3rd to August 5th.

The British Science Guild has been encouraged to organise this exhibition by the success which attended that held at King's College last summer, and the more recent exhibition at Manchester. It is hoped that this year's exhibition will be even more successful than its predecessors. The objects of the exhibition will be to illustrate recent progress in British science and invention and to help the establishment and development of new British industries. Such an exhibition will enable new appliances and devices to be displayed before a large public and will provide progressive manufacturers with an opportunity of examining inventions likely to be of service to them, thus serving as a kind of clearing-house for inventors and manufacturers, as well as illustrating developments in science and industry.

The exhibition will include sections dealing with chemistry, metallurgy, physics, agriculture and foods, mechanical and electrical engineering, education, paper, illustration and typography, medicine and surgery, fuels, aircraft and textiles. Firms desirous of exhibiting are invited to communicate with the Organising Secretary, Mr. F. S. Spiers, 82, Victoria Street, London, S.W.1.

TRADE NOTES.

The Willett Light.

We learn with interest that the "Willett Light" Business of Mr. William Willett has been purchased by the enterprising firm of Messrs. Mann, Egerton & Co., Ltd., the well-known Motor and Electrical Engineers, Norwich, Ipswich and London.

Messrs. Mann, Egerton & Co., Ltd., have been engaged for the past four years on building seaplanes and aeroplanes for the Admiralty and Air Ministry. The "Willett Light" plant will be made in the same works, under the same organisation.

Mr. Dean, who has been Manager of the "Willett Light" for many years, will remain in charge of the London Office and Showrooms situated at Willett Buildings, Sloane Square, London, S.W.1. Enquiries can be sent to above address or to their Norwich or Ipswich offices.

The Metric System and Publicity Literature.

In order to facilitate the development of overseas trade it is of great importance that both British and metric measures should be quoted side by side in catalogues for export. We are interested to observe that this practice has been adopted in a recent cata'ogue on Lanterns and Reflectors issued by the Wardle Engineering Co., Ltd., of Manchester. Dimensions and weights are given in both systems and we hope that this enterprising step will be adopted by other makers of lamps and lighting accessories.

·ELECTRICITY· ·ACETYLENE·
The
ILLUMINATING
ENGINEER
·OIL· ·GAS·
Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

The Tenth Anniversary Dinner of the Illuminating Engineering Society.

A little more than a year ago we celebrated the tenth anniversary of The Illuminating Engineer, and at a dinner held at the Trocadero Restaurant on March 18th, the completion of ten years of work of the Illuminating Engineering Society has now also been fitly recorded. The Society was actually formed on February 10th, 1909, and but for the disturbance of travelling facilities, the waiters' strike, etc., during February this year, the date of the dinner would have synchronised still more closely with the ten years anniversary of the Society's foundation.

The occasion was interesting not only as marking the tenth anniversary but also as the first gathering of the kind held since the outbreak of war. The Society was honoured by the presence of distinguished representatives of practically all the chief scientific and technical societies and Government

Departments concerned with its work. The President, Mr. A. P. Trotter, in reviewing the progress of the past ten years, referred to some of the difficulties anticipated in some quarters when the Society was first proposed. The suggestion that, for example, there would not be enough subject-matter for discussion, proved quite unfounded. The Society has never lacked interesting topics, and even the war, with its inevitable restriction of activities in some fields, only served to guide the efforts of the Society into new channels. Equally unfounded has been the fear that it would not be possible to provide a common platform for the rival efforts of representatives of gas and electricity, and other illuminants. This aspect was touched upon in the addresses of Mr. Thos. Goulden (Vice-President of the Institution of Gas Engineers) and Mr. C. H. Wordingham (President of the Institution of Electrical Engineers), both of whom congratulated the Society on providing a common platform for both industries, and remarked that future developments would probably favour still closer co-operation between the two industries.

We cannot here refer in any detail to the interesting addresses delivered by others among the guests. Readers will find a full account of the proceedings on pp. 93—104. The variety of topics touched upon, however, very aptly illustrated the wide field of interests of the Society, and there were many others who could have contributed other instances of this versatility, had it not been for the inevitable restriction of the list of speeches within reasonable limits.

In proposing the toast of "The Guests," the writer took the occasion to refer to one question of pressing interest to the Society—the initiation of legislative measures to ensure adequate industrial lighting. The Home Office in this country showed great enterprise in appointing a committee to investigate this question previous to the war, and its interim report, issued in 1915, represented a great step forward. But during the war the question has also been energetically taken up in the United States, and there are now five States which actually possess legislation dealing with the lighting of factories and workshops, and others are expected to follow. We therefore feel strongly that this country, which took the initiative in this matter, should regain the lead by making proper provision for the needs of the worker in connection with lighting in the Factory Act, and we are glad to note that Dr. T. M. Legge, H.M. Chief Medical Inspector of Factories, who has already done so much to encourage action in this direction, expressed sympathetic concurrence with this view.

One of the strongest arguments in favour of such supervision of industrial lighting is its relation to the safety of workers and the prevention of accidents. This point has been strongly emphasised in the United States, and Mr. H. C. Blain (Joint Honorary Secretary of the London "Safety First" Council) who also responded to this toast at the dinner, entirely corroborated this view out of his considerable experience.

And lastly, the writer feels he cannot let the opportunity pass without expressing his appreciation of the many kind references made to his efforts on behalf of the Society during the course of the evening. This work has been a labour of love, which has imposed sacrifices, especially during the war, but has justified itself by the successful emergence of the Society from this difficult period. He would like to associate with these appreciatory references the name of his assistant, Mr. J. S. Dow, whose association with him in this work since its commencement has been beneficial to the Society and to the movement generally.

The Need for Legislation on Factory Lighting.

One of the strongest inducements to adopt some suitable form of legislative supervision of industrial lighting is the close relation between good illumination and safety, to which may be added its importance in the interests of health, and efficient supervision and carrying out of work. These arguments are now generally conceded. They were put forward in the Report of the Departmental Committee on Lighting in Factories and Workshops in 1915, subsequently endorsed in the publications of the Committee on the Health of Munition Workers, and again mentioned in a reply to the question by the late Home Secretary in the House of Commons last autumn.

The time is therefore ripe for the recommendations of the Home Office Committee referred to above (namely that there should be statutory provision (a) requiring adequate and suitable lighting in general terms in every part of a factory or workshop, and (b) giving power to the Secretary of State to make Orders defining adequate and suitable illumination for factories and workshops or for any parts thereof or for any processes carried on therein) to be carried into effect. We may add that the experience gained in the United States fully confirms the desirability of such a step. When the writer, seven years ago, paid his second visit to the United States, this matter was beginning to receive attention. At a meeting of the American Illuminating Engineering Society, reported in the Transactions for October, 1912, he gave a summary of experience in Europe, and the matter was further emphasised in a full page interview which appeared in the New York *Times*. It was then pointed out by our American colleagues that the position in America was less favourable than in European countries, since each individual State would have to frame its own requirements independently. Accordingly some time elapsed before the lead given by this country through the appointment of the Home Office Departmental Committee was followed. However, once a start was made, progress was rapid. A full survey of the position is given in a recent paper by Mr. G. H. Stickney.* Industrial lighting codes, based on that prepared by the American Illuminating Engineering Society, are now in force in Pennsylvania, New York, New Jersey, Wisconsin and Oregon, and in others (including Ohio), bills providing for codes are before the legislature. In addition, by co-operation with the Bureau of Standards and the Federal Inspectors of Safety, a lighting safety code was adopted during the war in all Federal establishments, including arsenals, munition plants and navy yards.

There is thus ample precedent for action in this country. We do not suggest, for the present, detailed measures, such as might prove burdensome, but limit ourselves merely to the general requirement of adequate lighting, supplemented by more detailed information on the principles involved. As an instance we may mention the admirable full explanatory data which accompany the Wisconsin code. The practice adopted in the United States of arranging lectures on illumination for the guidance of inspectors might also with advantage be followed, and in course of time experience would enable the original requirements to be amplified. We feel sure that such a step would meet with ready acceptance on the part of manufacturers and workers. The matter is one that should receive attention, as an essential element in Reconstruction, at the hands of the international commission on industrial conditions which is deliberating in Paris, simultaneously with the Peace Conference.

***Proc. Amer. Inst. of Elec. Engrs.*, April, 1918.

Overseas Trade and the Press.

In this number (pp. 106—107) we give a summary of the address on the above subject delivered by Sir Arthur Steel-Maitland, Parliamentary Secretary to the Foreign Office and the Board of Trade, before a meeting called by the Circle of Scientific, Technical and Trade Journalists on April 4th. The subject is one of great importance at the present time. Sir Arthur pointed out that the financial strain involved in four years of war inevitably imposed disadvantages on this country in developing overseas trade ; there was, therefore, all the more reason to neglect no means of improving the position and to show the utmost enterprise in making good these inevitable deficiencies in other directions.

In addressing himself to the Press, Sir Arthur frankly recognised that trade and technical journals can do a great deal to develop British trade. In many cases their existing connections would enable them to furnish useful information on conditions in foreign countries, and in general their special knowledge of the industry with which they deal, would enable them to co-operate with the Board of Trade in presenting information in the right quarter and in giving an indication of the general course of events. Overseas trade rests primarily on the basis of mutual sympathy and knowledge of the countries concerned, and the mere fact of people in a foreign country becoming acquainted, through the medium of the Press, with the scientific and technical developments in this country predisposes them to cordial trade relations.

In another direction, the dissemination of ideas and information at home, the Press can aid trade development considerably. It is of vital importance that the present economic position should be generally understood, and that labour, especially, should appreciate something of the difficulties by which British firms are faced. It was therefore interesting to hear from Sir Arthur that a party leaving this country to study trade developments in the Far East is also to include representatives of labour.

Much of the discussion turned on the question of the supply of statistics and information to journals by the authorities. Discrimination must be exercised in giving publicity to facts of this kind, but some data can profitably be widely published. Sir Arthur took a most sympathetic view of the problem, suggesting that the matter might be the subject of arrangement between the Department and representative editors, and that, if desirable, periodical conferences might also be arranged, at which any questions could be raised and some general indication of trade developments given. He further expressed the willingness of the Department to meet any editor of a responsible journal and put him in touch with the section of the Department dealing with his special trade or industry.

Sir Arthur's enterprising action in co-operating with the trade and technical Press is an interesting instance of one gratifying change that the war has brought about, namely, a greater readiness of Departments to seek help wherever they can find it, and abandon the aloofness too characteristic of many of the authorities before the war. In so far as the Department of Overseas Trade is concerned, we think there is general agreement that it has done excellent work during the war, and we feel sure that with proper assistance and encouragement, it will be able to render substantial assistance to British trade in the critical years on which the country is now entering.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE TENTH ANNIVERSARY DINNER.

(Held at the Trocadero Restaurant, Piccadilly, London, W.C., at 7.30 p.m. on Tuesday, March 18th.)

THE Tenth Anniversary Dinner of the Illuminating Engineering Society was held at the Trocadero Restaurant, Piccadilly, London, W.C., at 7.30 p.m., on Tuesday, March 18th, the PRESIDENT (Mr. A. P. TROTTER) being in the Chair. It will be recalled that it was originally proposed to hold the dinner on February 11th, this being almost exactly ten years since the Society was first formed, but owing to the disturbance in travelling facilities, the waiters' strike, etc., the event was unavoidably postponed to the following month. The dinner was of special interest as marking the termination of ten years of work of the Society, and also as the first of such gatherings held since the outbreak of war. There was a representative assembly of members and guests, including the following :—

Sir George Beilby, F.R.S. (Vice-President of the Royal Society) ; Mr. Thomas Goulden (Senior Vice-President of the Institution of Gas Engineers) ; Mr. C. H. Wordingham, C.B.E. (President of the Institution of Electrical Engineers) ; Sir Frank Heath, K.C.B. (Secretary of the Department for Scientific and Industrial Research) ; Mr. D. B. Niven (Vice-President of the Royal Institute of British Architects) ; Mr. A. A. Campbell Swinton (Chairman of Council of the Royal Society of Arts) ; Sir Herbert Jackson, F.R.S. ; Col. J. Herbert Parsons (Council of British Ophthalmologists) ; Dr. T. M. Legge (H.M. Chief Medical Inspector of Factories) ; Mr. T. W. A. Hayward (President of the Institution of County and Municipal Engineers) ; Mr. R. C. Maxwell (Inspector to the Local Government Board) ; Professor R. A. Gregory (British Science Guild) ; Mr. F. F. S. Bryson (Optical Munitions and Glassware Supply, M.O.M.) ; Mr. H. J. Cash (President of the Electrical Contractors Association, etc. A full list of those present will be found on pp. 102–103.

Among those who wrote expressing regret at being unavoidably prevented from being present were Sir J. J. Thomson (President of the Royal Society) ; Mr. D. Milne Watson (President of the National Gas Council and Governor of the Gas Light and Coke Co.) ; Sir Anderson Critchett, Bart., K.C.V.O. (President of the Council of British Ophthalmologists) ; and Mr. F. Hinde (President of the Institute of Journalists).

Toast: "The Illuminating Engineering Society."

After the usual loyal toasts had been honoured, the toast of "The Illuminating Engineering Society" was proposed by Mr. THOS. GOULDEN (Senior Vice-President of the Institution of Gas Engineers), and seconded by Mr. C. H. WORDINGHAM, C.B.E. (President of the Institution of Electrical Engineers). The toast was coupled with the name of the PRESIDENT, Mr. A. P. TROTTER.

Mr. THOMAS GOULDEN (*Senior Vice-President of the Institution of Gas Engineers*) expressed his regret at the unavoidable absence of Mr. D. Milne Watson (President of the National Gas Council) and Mr. Samuel Glover (President of the Institution of Gas Engineers). He recalled the fact that the Illuminating Engineering Society was one of the youngest of the scientific societies, whereas the Institution of Gas Engineers celebrated its centenary about seven years ago. In spite of its youth, however the Society had done extraordinarily good work, one particularly good feature being that it had been instrumental in removing the old jealous rivalry that formerly existed between gas and electricity. Another feature was the collection of information in the Journal information which could not otherwise have been brought together. It had been of the greatest advantage to those who were in charge of the lighting of the country that this excellent information had been made available in the manner it had, and as a manufacturer of gas he wished to express his great appreciation of the work which the Society had done in this direction. The development of electric lighting had provided a great stimulus to the development of gas, and the result had been that to-day, notwithstanding the position of electricity, the gas industry was now able to give a light of 20 candles per foot of gas with an ordinary inverted burner, and from 60 to 80 candles with high pressure gas, against 3 candles per foot of gas when the Argand burner was in use in the seventies.

In the meantime the study of the best methods of using the light thus gained had been energetically taken up, and in this respect there had also been great advances, largely due to the efforts of the Society.

To-day the position was such that there was ample room for both gas and electricity. A great deal was said, in connection with reconstruction, of the possible developments of electricity, but the gas industry believed they could assist materially in this connection either by supplying gas or fuel for the generation of cheap electricity. They were willing and anxious to give every possible help in this way. He was glad to say that the gas industry was now in close touch with the electrical profession and its representatives had had friendly conferences with many eminent gentlemen in the electrical profession, and he had great hopes that something would be done by which the two industries would work together. If the war had done anything it had widened our horizons, whether in business or in private life, and we must now all feel that beyond our own immediate interests there was the very much greater interest of the country and the Empire as a whole. It was from that point of view that the gas industry hoped to be able to assist the electrical industry in the developments that were ahead.

He took it that the functions of the Society were two; first, the initiation of experiment and research in order to perfect artificial lighting, and secondly, the education of the public in the best use of the illuminants which were available. From the Proceedings of the Society it was quite clear that these two objects were being well carried out. The gas industry was fully alive to the importance of both objects and had taken special steps both in the direction of educating their staffs and in assisting the public.

Experience during the war, especially in connection with the demand for economy in lighting, had made it specially necessary for companies concerned with gas lighting to aid the consumer by advice. During recent years systems of maintenance, by which the lighting of the consumer was kept in good order so that he obtained the best results from his installation, had become general and would doubtless play an important part in the future. Generally speaking the object was to provide good service as well as gas, and it was most important that those in charge of this section of the work should be familiar with the latest advances in illuminating engineering. He was glad to note that the leading companies had accordingly arranged for a considerable number of their staffs to become members of the Society. They laid very great stress upon service to the public with regard to lighting, and he knew his electrical friends were not less behind in that matter.

As regards research, the gas industry fully recognised the great importance of encouraging experiments on illumination, and there were now a number of laboratories specifically devoted to these aspects of the use of gas. From the commencement of the Society's work the leading gas companies had shown their desire to co-operate in any way possible in the researches it initiated, and he might mention that the first model photometers used by the Society in its recent experiments for the Ministry of Munitions on flares and parachute lights, etc., were made in the workshops of the Gas Light and Coke Co.

It gave him great pleasure to propose the toast of "The Illuminating Engineering Society," coupled with the name of its President, Mr. A. P. Trotter, who had done so much valuable pioneering work in connection with the distribution and measurement of light.

Mr. C. H. WORDINGHAM (*President of the Institution of Electrical Engineers*) said that the Society, although only ten years old, had earned for itself a unique position in that it had gained the goodwill of everybody, which was a great thing to be able to say. He was particularly impressed with the sphere of operations of the Society, because it did two things which he had, in season and out of season, always advocated. First, it brought together the gas and electrical industries. He had consistently advocated that for many years past, and he had incurred some criticism in the past from both sides for having done so. He was, however, pleased to think that a change was coming over people's minds, although everything he would like to see had not yet been accomplished. He agreed with Mr. Goulden that there were opportunities for these two great industries to work hand in hand, and he could not but think it would be folly to throw away more than a century of experience in getting the best out of coal and to start *de novo* as if it were an experimental science which nobody knew anything about.

The next point was that of forming a society for a particular purpose. He had often preached the doctrine that whilst we had the Institution of Electrical Engineers to deal with electrical engineering generally, individual societies were wanted to deal with specific aspects of electrical engineering. A society such as this touched many other societies and professions; the medical profession, and the gas and electrical industries, for instance, and it knit them together. In that way these individual societies formed points of contact and so strengthened the whole fabric of engineering. The Society began by dealing with illuminating problems generally, and it had raised illuminating engineering to a science. It then went on to deal with specific subjects, and it considered the lighting of schools, streets, libraries, factories and even railways and railway stations. It had also co-operated with a number of different bodies and had assisted the Government Departments, notably the Home Office. He might refer especially to the informative report issued during the war by the Departmental (Home Office) Committee on Lighting in Factories and Workshops, as illustrating one field in which the Society's influence had been beneficially exerted. In the near future there would doubtless be fuller attention paid to this matter, and any steps likely to advance the general standard of lighting in factories and workshops would be received favourably both by the management and the workers, who were jointly interested. It believed in co-operation rather than in force, and that was a principle which we should do well to lay to heart in these days, when we were just recovering from the effects of being made to do everything. Let us keep our old British prejudice of every man being free, and obtain results by co-operation rather than by Prussian force.

The Society was fortunate both in its Honorary Secretary and in its Presidents. One could never think of the Illuminating Engineering Society without having before one the personality of Mr. Gaster, who had done an enormous amount of work for the Society, and had shown such enthusiasm and energy in the conduct of its affairs. Then as to Mr. Trotter, their President, he was sure that every member of the Society, as well as those outside, greatly appreciated the value of the work he had done not only for the Society but for the electrical industry generally. Mr. Trotter soared above the heads of all of them in this respect, and in the early days of the war he did so literally in the journey he made in the clouds to look down on the darkened streets of London. He had been privileged to read the most interesting account of that journey which Mr. Trotter had written, and he hoped the day was not far distant when that account would be given to the world.

The PRESIDENT (Mr. A. P. TROTTER), in responding to the toast, recalled that on February 9th, a little more than ten years ago, a party of 26 guests were invited to a dinner by Mr. Gaster to discuss the formation of the Illuminating Engineering Society. The tenth anniversary passed about a month ago, and this dinner would have synchronised with that date had it not been that certain sociological experiments were being tried which might have prevented them from having dinner, even if they had been able to gather together!

The first meeting of the Society was held on May 25th, 1909. One of the difficulties which some anticipated at that time was that there might not be enough subjects to go round, and that in consequence the Society would die a natural death in about two years. Another difficulty suggested was the impossibility of bringing together the representatives of the conflicting interests of gas and electricity, and possibly, oil, acetylene, and other illuminants.

The result they saw that evening. In spite of all that had been said regarding lighting becoming a small feature, both in connection with gas and electricity, enough had been found to provide work for the Society, and, owing to the energy of the Hon. Secretary, there had been no lack of subjects for discussion. Moreover, owing to his congenial personality and tactful guidance, the clashing of interests which had been feared had never been experienced. There had been a linking together of the various interests—of manufacturers of gas and electric lighting appliances, of others interested more particularly in such special problems as the lighting of streets, schools, libraries and factories, and what was the link that had enabled the conflicting interests to be united? It was science, and the scientific bases of the Society which had enabled that to be done.

The word "science" had many different meanings. An interesting paper was read about a month ago before the Royal Society of Arts on the relation of science to industry, and in the discussion of that paper the word "science" was used in two or three different senses, so that, when they came out into the outer world hardly two people could agree as to the meaning of the word. In the outside world there was no limit to the ways in which science was regarded. The time had gone by when science was loathed and detested as a wicked thing subversive of religion. There were still some literary men who affected to despise science, and some Government officials who rather disliked it, and the business man, also, was sometimes a little suspicious and cautious, especially when he met an expert. It was rather curious to find that among men who made science their life-study, specialisation had been carried to such a degree that it was possible to find a gathering of scientific people who scarcely understood each other's language. This demonstrated that there were many different kinds of sciences.

Walking across a Sussex field with a farmer last summer, he happened to mention science. The shrewd old man stopped and said: "Science is all very well, but what good is it to you or anybody else unless you make it pay? I would not claim that an acre of my land is any good unless I can make it pay."

The South Downs faded and he had a vision. Sir Isaac Newton, finding Clerk, Maxwell and Faraday in the upstairs smoking room of their club, said: "My *principia* is not going off well—what do you say to our going into partnership as a firm of consulting engineers ? My theory of light ought to bring in some illuminating business."

"I have knocked spots off that theory of yours," replied Maxwell, "but it seems to be a sound proposition. What do you say, Faraday ?"

"Don't be too sure about your electromagnetic theory, Maxwell. The quantum theory is sitting up and beginning to take notice, and Newton will have to work in an appendix on relativity. As for your proposition, I don't like propositions, they remind me of Euclid, and I am no mathematician. I have no theory of light, but I'll tell you what I *can* do. I have been making some optical glass at Albemarle Street. I think we could run a nice little professional practice together."

A fragrant cloud of smoke drifted past, and he looked again and saw an office in Caxton House. The firm were consulting engineers for Johannesburg. Their clients had sent an indent for glassware. The specification had been drawn (Newton wanted to write it in Latin, but Faraday strongly objected), quantities scheduled, samples submitted and tested, tender accepted, contract let, order given, conditions of contract settled, shipping invoice received, goods shipped, certificate issued. But the partners were discussing a telegram (telegraphic address "Newmaxfar, London") announcing "Forty per cent. broken, arrange replacement." Sir Isaac was annoyed. "Were they consigned C.I.F. ?" "No," replied Maxwell. "The order was F.O.B. Southampton. Our clients must take up the question of packing with the manufacturers, Beilby, Jackson and Co." "How do we come out of it ?" said Faraday. "We don't come out," said Newton, "we come in—for an annual retainer and 2½ per cent. commission."

And then, as they were putting through a trunk call to Stourbridge, the vision faded. He found his farmer friend whistling for his dog. He did not try to argue the point, as the farmer was perfectly right from his point of view. His (Mr. Trotter's) own point of view was a different one, and he felt it was a mistake to start an argument in that way. Science and business were mutually dependent on each other—something like capital and labour. Neither of them could afford to do without the other, and by combination there were no bounds to what could be done. It was by such combination that the Illuminating Engineering Society could help to bring about a brighter and a better England.

Toast: "Kindred Societies."

Mr. F. W. Goodenough (*Vice-President of the Illuminating Engineering Society*), in proposing the toast of "The Kindred Societies," said that since the inception of the Illuminating Engineering Society it had been fully recognised how necessary it was to co-operate with a great many scientific societies, because illuminating engineering touched upon a variety of interests. The Society was interested in the economical production of the sources of illumination which could be efficiently converted into light ; it was interested in the economical distribution and utilisation of that light, and it was interested in the design and arrangement of suitable fittings for the diffusion of light, so that they might give satisfaction to the domestic user and protect his eyesight. They were further interested in providing efficient illumination for the employee in the factory and workshop, in order to protect him from accidents, and the employer from consequential damage and diminishing output ; they were likewise interested in giving sufficient light in factories to maintain a good standard of health. Finally they were interested in the Press as the disseminator of information upon the subject of illumination.

At the same time, they realised that at the back of all the interests with which they were concerned they owed a particular debt to the scientific societies. They were very pleased to have with them that evening Sir George Beilby, Vice-President of the Royal Society. Sir George was not only a distinguished representative of the Royal Society, but was also at the present time head of the Fuel Research Board, which was doing extraordinarily valuable work in investigating the most economical way of utilising the fuel resources of this country and their conversion into sources of illumination. They had also a representative of the Royal Society of Arts, which had done a very great work in the promotion of the application of science to industry. The Royal Society of Arts had been a good friend to the Illuminating Engineering Society, which had enjoyed its hospitality since it was formed in 1909. But even before this date the Royal Society of Arts had done a great deal to interest the public in questions of illumination, dealing with each new illuminant as it developed, and he recalled that the course of lectures on Modern Illuminants delivered by Mr. Gaster only shortly antedated the starting of the Illuminating Engineering Society. Mr. A. A. Campbell Swinton, who was present as Chairman of Council of the Royal Society of Arts, was well versed in the principles of illumination, as the author of some of the earliest text-books on electric lighting and as one associated with much pioneering lighting work.

Another representative of a kindred society was Professor R. A. Gregory, of the British Science Guild, which had such an excellent record for the encouragement of applied science and the promotion of better facilities for technical education. Professor Gregory was known to be the possessor of a rare gift for the conveyance of scientific knowledge in an interesting form, as exemplified in his recent book on discoveries and inventions. The Society had co-operated in the British Scientific Products Exhibition, organised so successfully by the Guild during the past year, and they hoped to do so again in the further exhibition to take place during the present year.

They had hoped to have present with them Sir Anderson Critchett, surgeon to H.M. the King and President of the Council of British Ophthalmologists. Sir Anderson Critchett was unavoidably absent through indisposition, but they were fortunate in the presence of Col. J. H. Parsons, who was also associated with the Council and was well known to the members of the Illuminating Engineering Society as one of its Vice-Presidents who had taken a keen interest in the Society from its early stages. Col. Parsons was the author of many papers dealing with the effect of light on the eye—a subject in which the Society was naturally deeply interested. As an instance of fruitful co-operation with the medical profession in this field, he might mention its participation in the committee appointed by the Council to deal with the lighting of optical test charts.

Consideration of the effect of light on the eye led him to mention another of the guests, Mr. D. B. Niven, representing the Royal Institute of British Architects. Just as they needed the help of the oculist in studying lighting from the standpoint of vision, so they required the co-operation of the architect in devising methods of lighting which were not only economical and hygienic, but also pleasing. In the present age much of our life was passed under artificial light. In the past the architecture of buildings was determined largely by access of daylight; to-day it was necessary to consider how the design of a building affected artificial light as well and he felt sure that in this field the combined efforts of the architect and the lighting engineer would lead to valuable results.

Among other bodies represented he would like next to mention the Institution of County and Municipal Engineers, which, together with the Institutions of Gas and Electrical Engineers, had co-operated with the Society shortly before the war on the question of framing a standard specification for street lighting. While the discussions of this joint committee had revealed differences of opinion, they had led to much useful information being obtained. Mr. Hayward had taken a great interest in street lighting problems, and he felt sure that the influence of the Institution of which he was the President would continue to exert a beneficial influence in favour of better public lighting in London.

The addresses by Mr. Goulden and Mr. Wordingham had already illustrated the close connections which the Society had with the Institutions of Gas and Electrical Engineers, but he would like to refer to yet another kindred body, the Electrical Contractors' Association, whose President, Mr. H. J. Cash, was present at the dinner. Lighting installations rested very largely in the hands of the contractors, and the Society wished to receive their co-operation in the varied problems with which it had to deal.

He felt that he had by no means exhausted the list of Kindred Societies, but he had said enough to illustrate the wide sympathies of the Society. He wished to couple the toast especially with the names of Sir George Beilby, Col. J. Herbert Parsons, and Mr. A. A. Campbell Swinton.

Sir **George Beilby**, F.R.S. (*Vice-President of the Royal Society*), in replying, apologised for the absence of the President, Sir J. J. Thomson, owing to pressure of work at Cambridge in connection with the rush of students since the signing of the armistice. Before the war, he said, it might have been necessary to account for bringing the Royal Society into such a gathering because at that time the Royal Society had become very much the representative of so-called pure science in this country. In the early days the Royal Society drew no very sharp line between the applications of science and the pursuit of pure science for its own sake. As the years went on, however, applied science began very much to develop, and they had had the spectacle before them during the past generation of new societies starting every few years, and during the last ten or twenty years the number of these societies has increased enormously. He rejoiced at being present on the tenth anniversary of the Illuminating Engineering Society and congratulated them most heartily, on the appearance of the Society.

Since the war the whole position of the Royal Society had changed. From the very early days of the war the Royal Society set itself to establish committees on engineering, physics and chemistry, and it was a particularly notable fact that the men who joined these committees and began to deal with war problems on a scientific basis in nearly every case found their way into giving practical expression to science in the art of warfare. The President of the Royal Society had shown a most extraordinary grasp of the importance of this situation. It was at the foundation of these committees that he helped them forward in every possible manner, and he became so impressed with the importance of calling all societies together, and recognising that the Royal Society was the parent of all kindred societies in applied and pure science, that he proceeded to form his Conjoint Board of Scientific Societies. He did not know whether the Illuminating Engineering Society was represented on it, but from what he had seen and heard that evening it ought to be.

With regard to the Fuel Research Board to which reference had been made, it was far too soon to pretend to give any results of that work. It was going forward, and it was hoped to be able to help not only their gas friends but also their electrical friends. Problems were being studied which were interesting and of importance to these bodies, and it was hoped to be able to give answers to problems which they, in the turmoil of their business life, could not so calmly settle down to answer. The Board had Government resources behind it, not only finance, but influence and all that that meant, and it was hoped the Board would be able to answer some difficult problems that were coming up in the production of illumination and power.

Col. J. **Herbert Parsons**, replying for the *Council of British Ophthalmologists*, said that that body had been formed about a year ago to investigate problems with which the existing ophthalmological societies did not deal. Important matters in this connection were the testing of acuity of vision and the preservation of vision, which interested Government Departments considerably, but which the existing bodies, being scientific societies for the express purpose of dealing with diseases, apart from preventive medicine, did not touch. Preventive medicine, however, was very much to the fore, and rightly so, and the Council had been formed to investigate and give advice where it was needed. The aim was to make it a representative body which could freely offer its services to public bodies. Consequently, the Council had gone on the principle that it must justify its existence, and then probably public bodies would approach the Council for advice. One of the first matters examined was the illumination of test charts. The Illuminating Engineering Society was approached, and Mr. Gaster was appointed a member of the Committee which dealt with that matter. That was only one of the many things that was being done. Another was the standard of eyesight necessary for motor driving and also for railway engine drivers.

Mr. A. A. CAMPBELL SWINTON, on behalf of the *Royal Society of Arts*, referred to the prizes which that body had distributed during the 165 years of its existence for advances in science. Murdock, the inventor of gas lighting, was among the recipients. In more recent years both Sir Joseph Swan and Edison had been awarded the Albert Medal. During the war the Society had been able to render service to other societies in that the Hall of the Society was one of the few that had not been shut up, and it has thus been able to afford a meeting place for many other bodies. It seemed to him that the science of illumination had more scope than almost any other because at the present time our best methods of turning energy into light had an efficiency of 3 or 4 per cent., all the rest being wasted. There was thus ample room for development.

Toast: "The Guests."

Mr. LEON GASTER (*Hon. Secretary of the Illuminating Engineering Society*), in proposing the toast of "The Guests," said that during the war the Society had maintained old connections and had formed many new ties: The war had guided its researches into new channels, among these being the experiments on flares and the brightness of radioactive luminous paints (occasionally referred to by the President as the researches on "fireworks" and "fireflies") undertaken for the Ministry of Munitions. He was very glad to welcome as a guest Mr. F. F. S. Bryson, who had charge of this work for the Ministry.

General research in illuminating engineering had, however, also proceeded, and it would be recalled that a special committee to deal with this matter had been formed under the Department of Scientific and Industrial Research. In referring to the presence of Sir Frank Heath, who as Secretary of the Department had done so much to launch it on its career of usefulness, he would like to make special mention of the newly-formed Research Board on Industrial Fatigue. This was a subject of absorbing importance at the persent time, and he felt sure that, in the researches of the Board, the effects of inadequate lighting, as a contributory cause of eye and general fatigue, would receive attention.

An important step had already been taken during the war by the publication, in 1915, of the Interim Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops. The work of this Committee formed a fitting culmination to the pioneering work which the Society had done, at international congresses and elsewhere, on industrial lighting. He took this opportunity of acknowledging the sympathetic interest which Dr. T. M. Legge, H.M. Chief Medical Inspector of Factories, and the late Chief Inspector of Factories, Sir Arthur Whitelegge, had taken in this subject. To them was largely due the credit attaching to the Home Office for having taken the initiative in dealing officially with this important subject. During the war the conclusions of the Committee had been strongly endorsed by the booklet issued by the Health of Munition Workers Committee, and Viscount Cave, the late Home Secretary, had expressed his conviction as to the importance of good industrial illumination, and had paid a compliment to the work of the Committee in the House of Commons last autumn. Having proceeded so far, he trusted that the work of the Committee would be carried to its logical conclusion by the introduction of a suitable reference, requiring adequate lighting, in the Factory Act, which he understood would be undergoing revision shortly.

It was interesting to observe the course of events in the United States. About seven years ago, when he visited the States he referred to the prospects of legislative measures in regard to proper factory lighting in Europe at a meeting of the Illuminating Engineering Society (U.S.A.). The matter was also emphasised in a full page illustrated interview with him which appeared in the New York *Times*. Since that date progress had been rapid, and there were now seven States which had adopted legislative codes on industrial lighting, largely modelled on the recommendations of the American Illuminating Engineering Society. During the war circumstances had hindered similar steps in this country. Now, with the incubus of the war removed, it was to be hoped that this country would regain the lead which it formerly held. Moreover, the attention which Labour was giving to conditions of work would doubtless include industrial lighting, and he hoped that the matter would receive study at the hands of the international labour committee now sitting in Paris.

One highly important aspect of factory lighting, the value of good illumination in preventing accidents and ensuring safety, fell within the field of the newly formed British Industrial " Safety First " Association, an off-shoot of the London " Safety First " Council which had already done such good work in materially reducing the number of accidents in streets. He felt sure that similar success would attend the application of " Safety First " methods in the industrial field, and he was very glad to welcome Mr. H. C. Blain, the energetic Joint Hon. Secretary of the Council, in co-operation with which the Society had done a great deal of interesting work since the outbreak of war.

He wished also to express their pleasure at the presence of Mr. R. C. Maxwell, one of the inspectors to the Local Government Board, who was likewise closely associated with the London " Safety First " Council. This led him to mention another important field of inquiry, the effect of bad conditions of illumination in causing progressive deterioration of vision and even ultimately blindness. The causes of blindness had been the subject of much study, and the Local Government Board had recently devoted a large sum to the alleviation of the lot of the blind. This was emphatically a case in which prevention was better than alleviation, and he hoped that the part played by poor illumination in inducing defects of vision would be closely studied.

Mr. Gaster next paid a tribute to the sympathetic co-operation which the Society had received from the daily and technical Press, in giving wide publicity to the Society's work. During the war they had all learned to appreciate, even better than in past years, the power of the Press. They had hoped to have the pleasure of the presence of Mr. F. Hinde, the President of the Institute of Journalists, but he had been unavoidably detained at the last minute.

Finally, Mr. Gaster referred to the presence of Professor Miluikoff, the well-known Russian statesman, recalling that some years ago it had been proposed to form a society to deal with illumination in Russia. He hoped that when conditions became more settled this movement would be renewed.

He had much pleasure in proposing the toast of " The Guests," with the names of Dr. T. M. Legge and Mr. H. C. Blain.

Dr. T. M. LEGGE (*H.M. Chief Medical Inspector of Factories*), replying, expressed his sympathetic concurrence with the views expressed by Mr. Gaster in regard to industrial illumination. He recently read some figures given by an American insurance company to the effect that of 91,000 industrial accidents, no less than 23 per cent. were due to defective lighting. It was also stated that in the last two years, due to efforts to improve lighting, these accidents had been reduced by 30 per cent. There was not now a single conference with employers and employees at the Home Office at which lighting was not discussed. Only last month, in a conference with representatives of the boot and shoe trades, lighting was discussed, and an unanimous agreement was come to that as regards natural lighting, underground workrooms should be prohibited in any new works. As regards existing works, no underground rooms were to be continued in use after a period of three years unless a certificate was given by H.M. Inspector of Factories that he was satisfied with the conditions as regards lighting, ventilation, etc. It was also decided that artificial lighting should be adequate and the lamps must be so placed as to prevent as far as possible the rays impinging on the eyes of the workers. He sometimes wished there could be a little simpler definition than the strictly scientific one of what good lighting should be. In the recent report of the Departmental Committee on Lighting in Factories and Workshops it was laid down that " the lighting should

Professor R. A. Gregory
(British Science Guild)

Mr. R. C. Maxwell
(Inspector to the Local Government Board)

Mr. H. C. Blain
(Joint Hon. Secretary of the London "Safety First" Council)

Mr. Thos. Goulden
(Senior Vice-President of the Institution of Gas Engineers)

Mr. D. B. Niven
(Vice-President of the Royal Institute of British Architects)

Sir Geo. Beilby, F.R.S.
(Vice-President of the Royal Society)

Mr. F. F. S. Bryson
(Optical Munitions and Glassware Supply, M.O.M.)

Mr. H. J. Cash
(President of the Electrical Contractors' Association)

Mr. W. R. Rawlings

Major H. C. Palmer

Mr. C. Wilson

Captain C. F. Trippe

Mr. A. Wise

Mr. H. C. Wheat

Mr. J. E. Edgcome

Mr. F. W. Willcox

Mr. Roger T. Smith

1

Mr. W. C. Clinton

Mr. C. C. Paterson, O.B.E.

Mr. J. Y. Fletcher

Mr. F. P. Driver

Mr. G. Cheliote

Mr. Cole

Lt. H. N. Green

Mr. P. Whysall

Captain MacCallion

Mr. W. E. Bush

Mr. F. Shaw

Mr. J. G. Clark

Mr. A. H Dykes

Sir Herbert Jackson, F.R.S.

Professor Miluikoff

Mr. Singman

Mr. Singman's friend

Mr. J. Scrivener

Captain S R. Mullard

Captain E. Stroud

2

Mr. A. Webster

Mr. A. J. Sturgeon

Major K. Edgcumbe

Lt.-Col. F. A. Cortez-Leigh

Mr. J. J. Kelly

Mr. F. S. Dennison

Mr. G. Campbell

Mr. E. S. New

Mr. J. Wyatt Ife
(Hon. Treasurer).

Mr. Haydn T. Harrison.

TENTH ANNIVERSARY DINNER of the

Held at the TROCADERO RESTAURANT, Piccadilly,

Mr. C. H. Wordingham, C.B.E.
(President of the Institution of Electrical Engineers)

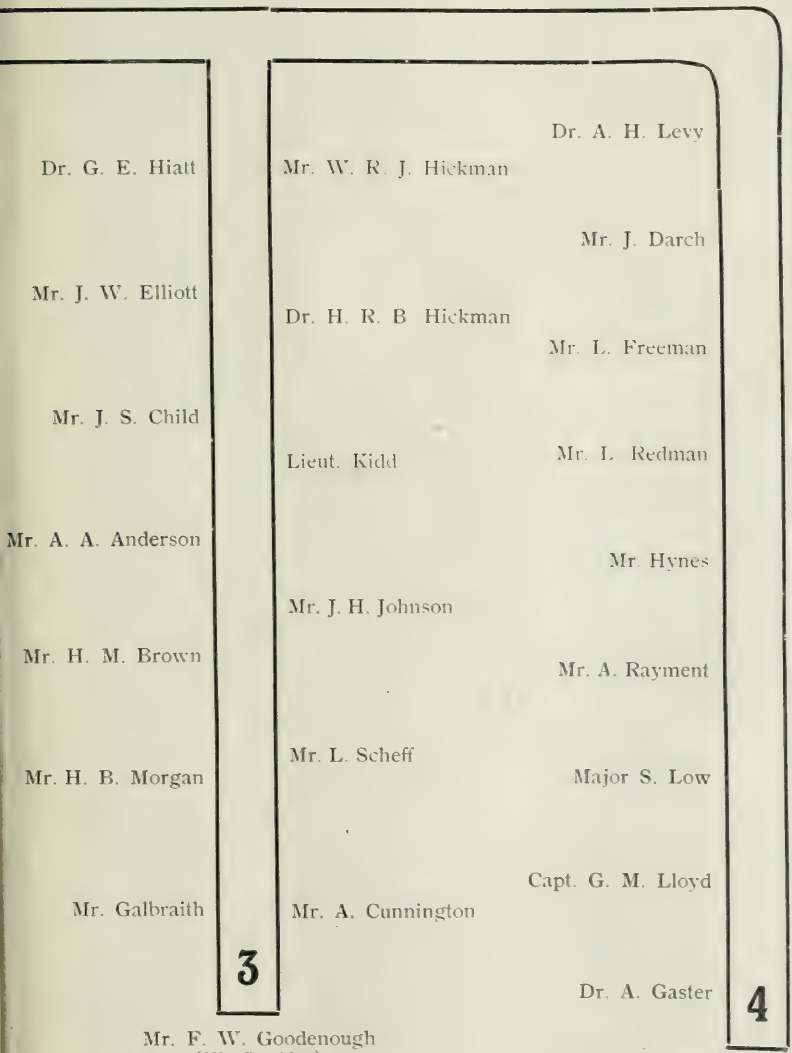
Mr. A. A. Campbell Swinton
(Chairman of Council of the Royal Society of Arts)

Sir Frank Heath, K.C.B.
Secretary of the Department for Scientific and Industrial Research

Col. J. Herbert Parsons, D.Sc., F.R.C.S.
(Council of British Ophthalmologists)

Dr. T. M. Legge
(H.M. Chief Medical Inspector of Factories)

Mr. T. W. A. Hayward
(President of the Institution of County and Municipal Engineers)



Dr. G. E. Hiatt
Mr. J. W. Elliott
Mr. J. S. Child
Mr. A. A. Anderson
Mr. H. M. Brown
Mr. H. B. Morgan
Mr. Galbraith

Mr. W. R. J. Hickman
Dr. H. R. B Hickman
Lieut. Kidd
Mr. J. H. Johnson
Mr. L. Scheff
Mr. A. Cunnington

Mr. F. W. Goodenough
(Vice-President).

Dr. A. H. Levy
Mr. J. Darch
Mr. L. Freeman
Mr. L. Redman
Mr. Hynes
Mr. A. Rayment
Major S. Low
Capt. G. M. Lloyd
Dr. A. Gaster

Captain J. Levy
Dr. James Kerr
Dr. Chaikin
Mr. Gowans Whyte
Mr. S. Davis
Dr. R. Lessing
Mr. G. Herbert
Mr. J. S. Dow
The Times

Mr. L. Gaster
(Hon. Secretary).

Illuminating Engineering Society, (FOUNDED IN LONDON 1909)

ondon, W.C., on Tuesday, March 18th, 1919.

be such that the illumination measured in a horizontal plane at floor level shall be not less than 0·25 foot-candle."

This was doubtless satisfactory as an indication to the lighting engineer of the amount of illumination requisite in the interests of general convenience and safety (apart from the illumination needed for the actual carrying on of work) when coupled with suitable recommendations as regards avoidance of glare, elimination of inconvenient shadows and other essential points. But for the ordinary works manager some simpler general statement, which could be reinforced by more detailed recommendations, was needed, and they had fallen back upon the general statement that the lighting should be ample in all respects. It had given him great pleasure to be present at the dinner, and to observe the progress that had been made since he first came in contact with the Society.

Mr. H. C. BLAIN (*Joint Hon. Sec. of the London "Safety First" Council*) said that on behalf of his Council he wished to express their indebtedness to the Illuminating Engineering Society for the great assistance it had been in the work of the Council. Mr. Gaster was the representative of the Society on the Council, and during the past two years they had been successfully endeavouring to cope with the large number of accidents in the streets which had been due largely to the lighting conditions. In the recommendations which had been made to the local authorities and to the Government departments concerned with street lighting, they had had the greatest possible assistance from the scientific knowledge and enthusiasm which Mr. Gaster, in his capacity as Chairman of the Sub-committee dealing with street lighting work, had brought to bear upon the problem.

He felt, also, that in the larger sphere of the Industrial "Safety First" Association there should be a very great future indeed for the application of the principles of good lighting as advocated by the Illuminating Engineering Society. In this Association the Illuminating Engineering Society was also appropriately represented by its Hon. Secretary, Mr. L. Gaster. There was no phase of factory administration where there was the possibility of greater improvement than in the scientific application of illumination, and he was distinctly hopeful that at no distant date it would be possible to direct the attention of factory owners in this country to the necessity of dealing promptly and expeditiously with that side of the "Safety First" movement.

In conclusion, THE PRESIDENT proposed the **Toast** of "**His Majesty's Forces,**" voicing the general admiration of the efforts of all branches of the Services, now happily carried to a victorious conclusion.

THE USE OF THE SELENIUM CELL AS A SAFETY-APPARATUS.

THE idea of using the sensitiveness of selenium to light as a device to give warning of fire is not new, but it appears to have been exploited in a very practical form in an apparatus recently produced in Germany and described in the *Schweizerische Electrotechnische Zeitschrift**

The so-called "electrical eye" consists of a selenium cell in series with a battery, which by means of a relay rings a bell as soon as the faintest light impinges on it. Accordingly if a fire starts in a room by night the light of a flame will give a warning. The apparatus is also intended as a precaution against burglars, who presumably would invariably require *some* light for their operations. It is remarked that the light of a match at a distance of six metres is sufficient to set the alarm going; even if a person strikes a match with his back to the cell, the feeble reflected light is often sufficient to give the indication. In general the alarm was given within ten seconds of the kindling of the light. During working hours the apparatus is disconnected so that it will not be affected by daylight.

---

* March 15th, 1919.

Obituary.

SIR WILLIAM CROOKES, F.R.S., O.M. Born June 17th, 1832. Died April 4th, 1919.

By the death of Sir William Crookes science loses yet another of its greatest figures. Sir William was typical of the band of enthusiasts who did so much to raise the prestige of this country in the world of science during the latter half of the last century. He died at the advanced age of 86 years. He seems to have been born with an innate taste for scientific matters. He pursued his investigations up to the very last, and his long life was filled by researches of the most varied nature. It is related that at the age of ten he had already set up a little laboratory of his own. At the British Scientific Products Exhibition last year there were exhibited specimens of the rare mineral scandia, recently discovered by him, and his series of glasses for the absorption of excessive infra-red and ultra-violet rays.

It would be impossible, within the space available, to give even a summary of his main achievements. To the general public Sir William was known for his work on spectroscopy, as the discoverer of the element thallium through its aid, and through his epoch-making researches on radiant matter familiarly associated with the "Crookes tube." It was his famous discoveries in the latter field that led to the use of the Röntgen rays, and his theories of ultra-gaseous matter were strikingly confirmed by the subsequent discovery of radium.

But he was equally eminent in the field of applied science. His researches on high vacua made the incandescent electric lamp a commercial possibility, and his own house in Kensington Park Gardens is said to have been the first in this country to be lighted with electricity. He was equally a chemist and a physicist, and was the author of many contributions dealing with the chemistry of dyeing and photography, water-purification and other problems. He undertook much literary work, and was associated with many different scientific societies.

In him the Illuminating Engineering Society had, from its commencement, a firm friend. He was created one of the first Vice-Presidents of the Society in recognition of his distinguished services to illumination, and in spite of advancing infirmity, he attended the last Annual Dinner of the Society held previous to the war, when as President of the Royal Society he spoke a few words of encouragement in recognition of the Society's work. On the occasion of the Tenth Anniversary of this journal, at the commencement of last year, he wrote a special message of congratulation, adding, "I am very glad to have the opportunity to express my appreciation of THE ILLUMINATING ENGINEER. It is always full of interest. The national importance of a clear knowledge of the laws of light with special reference to illumination is unquestionable. The subject is a very large one, embracing not only natural and artificial light, but also the effects of it upon the eye. . . . I wish the journal every success."

Although his achievements brought him the greatest honours that science can confer, including the Order of Merit, he remained, like all great discoverers, unassuming, approachable and kindly to all with whom he came in contact, with a generous recognition of the work of others. His death is a great loss, not merely to science, but to the whole world.

OVERSEAS TRADE AND THE PRESS.

An address on the above subject was given by Sir Arthur Steel-Maitland, Bart., Parliamentary Secretary to the Foreign Office and the Board of Trade, before a gathering called by the Scientific Technical and Trade Circle of the Institute of Journalists, at 5 p.m. on April 4th.

The chair was taken by Mr. L. Gaster, who, in a few introductory remarks, recalled that at a meeting held at the Stationers' Hall in April last year a paper was read by Mr. Sewell on some aspects of the development of British trade, and a resolution was then passed urging on the President of the Board of Trade the desirability of utilising to the fullest extent the resources of the trade and technical Press. This resolution was brought to the notice of the authorities and a sympathetic reply was received. Subsequently Sir William Clark, Controller of the Overseas Trade Department of the Board of Trade, kindly undertook to address the Circle, but this pleasure was deferred owing to his departure abroad on important business.

Sir Arthur Steel-Maitland had now kindly consented to address the Circle on the subject of "Overseas Trade and the Press," and he felt sure that all present appreciated the vital importance of this matter, and desired to further the aims which Sir Arthur's department had in view.

Sir Arthur Steel-Maitland, in rising to address the meeting, expressed his desire to secure fuller co-operation with the technical and trade Press, who, he fully recognised, could do a great deal to assist the development of British Overseas Trade. He wished first of all to point out one or two obstacles which had to be overcome. There was first the difficulty of securing the reversion of factories engaged in war work to normal work, and the question of securing the necessary supplies of raw materials. Furthermore, it was recognised that the Overseas trade of the immediate future would involve giving considerable credit, which was naturally a difficulty to a country which had borne the immense financial strain of the war. Then, again, the cost of manufacture and rates of wages had enormously increased. He mentioned these facts merely to show the vital need for extra energy and efficiency in manufacture in order to secure the necessary increased production.

As regards the point last mentioned, he was in full sympathy with the desire of labour for better conditions of life. He felt, however, that it was necessary that labour should realise something of the difficulties owners of businesses would have to meet, and be ready to share in the task of overcoming them. This could only be done by co-operation, and it was of interest to mention that a mission which is to inquire into conditions of trade in the Far East will contain also representatives of labour.

The work of his department might be regarded as falling under three heads: (1) the development of British Overseas Trade, (2) the encouragement of British enterprise abroad, and (3) the study of sources of the raw materials for industry. In connection with the second point it was important to recognise that the promotion of British enterprise abroad was often responsible for a substantial amount of British trade. For example, the fact of the leading railways in the Argentine have been built by this country probably accounted for a large proportion of the annual British trade with the Argentine. Raw materials were also most important and it would be noted that large manufacturing concerns were now taking steps to own adequate supplies of commodities needed in their respective businesses. Thus motor-car companies owned rubber plantations, which furnished material for tyres; electrical manufacturing companies were interested in securing supplies of copper, mica, rubber and other materials which they needed.

Another tendency of the moment was towards the amalgamation of small businesses into large ones. There were many cases in which a large firm could not only maintain better facilities for obtaining trade but could also manufacture more cheaply, and it was imperative that amalgamation should proceed until the stage of maximum efficiency of production was attained. Another important element in efficient manufacture was the specialisation of firms on certain classes of articles. When a very great variety of products was dealt with in the same factory it was difficult to attain the highest stage of perfection ; but if various firms in the same industry agreed to devote themselves to particular sections of the work, and then exercised combined effort in assembling and disposing of the complete article, much better results were secured. In regard to the study of foreign trade, the co-operative effort of federations of firms concerned in an industry was also an important factor ; in the future it would be necessary for firms engaged in the same business to help each other much more, and to pursue a common policy, instead of acting as self-contained independent units.

Sir Arthur then proceeded to show, by illustrations, how the Department of Overseas Trade had been able to assist British Trade materially in many cases, even in spite of the difficulties arising through the war. Now that these special hindrances to trade were disappearing they hoped to be able to do much more. One point that should be appreciated was the need for some channel of connection between the Foreign Office and the Board of Trade as there were many cases in which a trade inquiry took on a political aspect, or *vice versa.* The present arrangement, providing for such co-operation, had already been helpful in several instances. He was fully aware of the need for re-organising the consular service, and already they had taken steps towards improvement, and would do more, with proper resources.

In conclusion, Sir Arthur said that the main object in addressing the meeting had been to express his desire for co-operation with the Press, and to hear any suggestions as to how the resources of the Press could be more fully utilised. One thing he wished to make clear, that his Department was most anxious to get in touch with any editor who desired to make suggestions regarding the industry with which he was identified, or who required specific information which the Department might be able to supply. He would be very glad to welcome any editor of a recognised trade or technical paper and to put him in touch with the head of the department concerned, who would give him all particulars he desired. With regard to the publication of information, it must be remembered that while in many cases publicity was helpful, there were also cases in which it did not seem advantageous for information to be generally known, though it could be shown confidentially to journalists who desired to be informed of the situation, and thereby be guided in the references they proposed to make in their journal. He hoped, however, that the Press would realise the difficulties under which the Department was still labouring, especially as regards the shortage of staff, which was quite inadequate in comparison with the magnitude and importance of the work involved. This point should be borne in mind in judging any shortcomings in present procedure.

The ensuing discussion dealt largely with this latter point, and the suggestion was made that there should be frequent conferences with the trade and technical Press, at which information regarding the general tendency of trade could be discussed, and any points that required attention brought before the notice of the Department.

Sir Arthur welcomed these suggestions, and added that any others would receive attention, either if sent direct to him or conveyed through the Chairman of the Circle, Mr. Gaster.

A cordial vote of thanks to Sir Arthur was proposed by Mr. Herbert Cornish, Consultative Secretary to the Institute of Journalists, and seconded by Mr. G. T. Simmons, Treasurer of the London District of the Institute, and carried with acclamation.

THE GROUP AND DUCT SYSTEM OF HIGH PRESSURE GAS LIGHTING.

AT a meeting of the Yorkshire Junior Gas Association in March last Mr. F. Pykett read a paper describing the application of the Keith group and duct system of lighting in a cotton spinning mill in Halifax. An account of the paper appeared in the *Gas World*.* In this system there are three separate sets of pipes, one supplying high pressure gas, one carrying air to an injector for mixing with the gas, and one supplying the mixture of air and gas from the injector to the burners. Each individual burner has a gas injector and intake, but one injector is used to supply a group of burners, and air can, if desirable, be drawn from outside the building. This latter point is of importance in the case of factories where there is much dust or fluff likely to be drawn in with the air, as in the cotton mill here referred to.

In this installation the five lower floors were lighted by electricity, the upper floors previously by flat flame gas burners for which the high pressure incandescent system was now substituted; 179 300-candlepower and 71 150-candlepower burners displaced the flat flame burners, gas being supplied at 80 in. pressure by a Keith rotary compressor. With slight alterations the existing points were used, and the piping arrangements for the installation are described in detail in the original paper. The system seems to have disposed of any difficulties arising from the fluff in the atmosphere, after certain modifications in a few sections had been made. Stress is laid on the low maintenance costs, especially in the renewal of mantles, glass, etc. A very notable reduction in cost of material (from £21 4s. 3d. to £12 12s. 8d.) was achieved in 1918-19 as compared with 1917-18.

---

* March 29th, 1919.

SUBDUED LIGHTING OF SIGNAL-BOXES.

MR. CUNNINGTON sends us the following extracts from a letter on the above subject which he has received from Mr. W. C. Acfield, Signal Superintendent of the Midland Railway, and with the sentiment of which he is strongly in agreement:—

"It has always been my idea that the illumination of signal-boxes should be reduced to a minimum, of course giving sufficient light for the signalmen to do their work, and this idea is confirmed over and over again in some hundreds of signal-boxes where the signalmen have devised all sorts of impromptu screens and shades with peep-holes sufficient for the light to be thrown on to the block instruments and train register books.

"One of the most satisfactory methods which has been adopted on this line is a metal cylinder about 8 in. long and 4 in. diameter, fixed to inverted burners suspended from the roof of the signal-box over the signalman's head, as a globe, slits being made in the cylinder to throw the light on to the block instruments, lever handles, train register books, etc. This prevents brilliant reflection in the end windows of the signal-box, and from practical experience it is impossible for the signalman to see satisfactorily train movements on the line at night-time if the signal-box is in any way brilliantly illuminated. What is going on outside the signal-box is obliterated by the reflection of the apparatus in the signal-box on the end windows. When a signalman requires to open and look out of the window of a brilliantly illuminated signal-box it is some seconds before the eye can get accustomed to the darkness outside.

"I think it would certainly be a good plan if the gentlemen responsible for the lighting arrangements on railways could arrive at some standard method of illumination, or rather of obtaining the minimum amount of illumination necessary to do the work in the signal-boxes."

MESOTHORIUM AS A SUBSTITUTE FOR RADIUM IN LUMINOUS PAINT.

In a circular issued by the Bureau of Mines, U.S.A., in December last, attention was drawn to the growing demand for radium, not only for medical work, but as an ingredient in luminous paint, which renders the question of possible radioactive substitutes of great importance. The luminous paint used in practice contains usually from 0·1 to 0·25 milligrammes of radium element to one gramme of zinc sulphide and the luminous dial of a watch may contain ten to twenty cents (5d. to 10d.) worth of radium on it.

Among the possible substitutes for radium salts proper is mesothorium, found in monazite and other thorium minerals. As the energising value of this substance only builds up gradually after extraction, several months or even a year must be allowed for it to ripen. By this time the alpha radiation required for luminous paint becomes sufficiently strong for effective use. The beta and gamma radiation, on the other hand, which can be used for medical purposes, are available in sufficient strength a few days after preparation of the substance.

There is, however, another property distinguishing this material from radium. While the latter has a long life (probably decaying to half its value in 1,600 years), the useful life of mesothorium is relatively short, only five to six years being its useful period as regards its employment in luminous paint. This is one reason why radium is often preferred in spite of its higher price (hitherto about twice that of mesothorium for equal activity). In the long run radium is vastly the cheaper, as its activity does not diminish appreciably in a generation. In purchasing mesothorium, however, it is necessary to know its pedigree before one can estimate its useful value. Thus mesothorium purchased five years after preparation would presumably have lost almost all its value as an ingredient in luminous paint, while even after two years its strength would have become impaired; on the other hand, if it were purchased a few weeks after preparation, a growing activity, extending over months, and possibly over a year, would be observed, before the final fall in strength set in.

The ultimate diminution in the activity of mesothorium itself should, of course, be distinguished from the decay in brightness of luminous paint due to the destructive effect of radium radioactive bombardment of the zinc sulphide, recently discussed before the Illuminating Engineering Society. In the case of mesothorium this decay would take place in addition to the weakening of the bombardment itself in course of time. Both effects would ultimately hasten the decay in brightness, though, for the reason explained above, the brightness might first increase for a time if the mesothorium employed were immature. With radium, on the other hand, we are practically only concerned with the diminution in response to bombardment of the zinc sulphide.

When the brightness has decayed sufficiently to no longer serve its purpose the radium can be extracted and made up again with fresh zinc sulphide. On the other hand, after a life of several years, it would probably not be worth while to extract mesothorium from luminous paint as it would have lost much of its original value.

Mesothorium, therefore, seems best adapted to objects which are only required to have quite a short life and are not preserved afterwards. It appears to have been used to a considerable extent in Germany during the war, but until recently little had been extracted in the United States, and probably, also, little in England. Shortly after the United States entered the war the Bureau of Mines made a co-operative agreement with the Welsbach Company in Gloucester, N.J., for the study of methods of extracting and recovering mesothorium from residues accumulated in the manufacture of incandescent mantles. Mesothorium is now one of the regular products made by this company, and other concerns have likewise become interested in the process. At the present time mesothorium is extracted from practically all the monazite sand treated in the United States.

It will be interesting to watch the development of this new industry. Although the price charged for mesothorium in the past appears high, bearing in mind its short life as compared with radium, it seems probable that, with its manufacture on a large scale as a by-product in the incandescent mantle industry the cost might be very considerably diminished. If this were the case, and if large stocks of the material became available, this would doubtless lead to a considerable extension of the purposes for which radioactive self-luminous paint was applied in practice. Its use might, for example, become quite usual for coating switches, key-holes, door-numbers, etc., and other objects which require to be seen in the dark. It seems probable, however, that for important Government work radium would still be chiefly used on account of its more permanent value.

THE METALLOGRAPHY OF TUNGSTEN.

In a recent contribution to *Engineering* Mr. Z. Jeffries discusses the structure of tungsten used for lamp filaments. Of special interest is the addition of a small amount of thoria (usually 2 per cent.) which controls the direction and degree of "grain growth," so as to produce a robust structure. The grains should be fairly small, 6,000 per sq. mm., but not too small, otherwise the material becomes hard to work. When used at the rated voltages the filament temperature should be above the recrystallising temperature of the metal, but even so the grains tend to become elongated during life; this gives greater stiffness, but if the process goes too far there is a danger of "off-setting"—*i.e.*, the displacement of sections of the filament perpendicular to the axis.

THE LIGHTING OF SAN FRANCISCO HARBOUR.

The *Electrical Review and Western Electrician* gives an interesting account of some of the measures being taken to light the harbour of San Francisco, which is publicly owned and now comprises 46 piers, a belt railway line, ferries, and numerous repair shops, storehouses, etc. An interesting feature of the street and pier lighting in the vicinity of the harbour is the system of remote control from the office of the chief electrical engineer, four miles away. Pier illumination has recently been improved by the introduction of gas-filled lamps and by special flood-lights (1,000-watt projectors) used to illuminate ships tied up along the docks. Other 100-watt units are set apart to facilitate unloading by night. The lighting of the interior of the docks is done by 250-watt lamps in metal reflectors, 90 feet apart. Another feature of interest is the illumination of the large clock face, 24 feet in diameter, with a minute hand 11 feet in length.

PERSONAL.

Capt. S. R. Mullard, M.B.E., who is a member of the Illuminating Engineering Society and who was for many years connected with the lamp manufacturing side of the Ediswan Electric Co., Ltd., has been demobilised from the R.A.F., and has joined the "Z" Electric Lamp Manufacturing Co., Ltd., of Southfields, as Works Manager.

We wish Captain Mullard success in his new position.

We learn with interest that the three sons of Mr. O. P. Macfarlane, Managing Director of Messrs. Blanchard (British) Lamps, Ltd., all of whom have been serving with the Forces during the war, have now been released and re-entered the business. Captain Gordon Macfarlane, R.A.F., is again taking charge of the Sales Dept., Captain Malcolm Macfarlane, M.C., R.E., is Works Superintendent, while Lieut. Ivor Macfarlane (Mons Star) is acting as Secretary and Works Manager.

We learn with great regret of the death of Mr. A. D. Hunter, Chief Assistant Secretary of Messrs. Siemens Brothers Dynamo Works, Ltd., which occurred on April 17th. Mr. Hunter was 50 years of age. He entered the service of the allied company of Messrs. Siemens Bros. and Co., Ltd., in 1889, and in 1908 assumed the position which he held at the time of his death.

INDEX, April, 1919.

PAGE
Canadian Mission in London, The 112
Editorial. By L. GASTER 89
Group and Duct System of High Pressure Gas Lighting, The 108
House of Commons, Night Sittings in the 112
Illuminating Engineering Society—
(Founded in London, 1909)
Tenth Anniversary Dinner, held on March 18th:
Addresses by:—
Mr. THOMAS GOULDEN (Senior Vice-President of the Institution of Gas Engineers)—Mr. C. H. WORDINGHAM (President of the Institution of Electrical Engineers)—Mr. A. P. TROTTER (President of the Illuminating Engineering Society)—Mr. F. W. GOODENOUGH (Vice-President of the Illuminating Engineering Society)—Sir GEO. BEILBY, F.R.S. (Vice-President of the Royal Society)—Mr. A. A. CAMPBELL SWINTON (Chairman of Council of the Royal Society of Arts)—Col. J. HERBERT PARSONS (the Council of British Ophthalmologists)—Mr. L. GASTER (Hon. Secretary of the Illuminating Engineering Society)—Dr. T. M. LEGGE (H.M. Chief Medical Inspector of Factories) Mr. H. C. BLAIN (Joint Hon. Secretary of the London "Safety First" Council) 93
Mesothorium as a Substitute for Radium in Luminous Paint 109
Obituary—Sir William Crookes, F.R.S., O.M. 105
Overseas Trade and the Press 106
Personal Notes 110
Railway Signal Boxes, Lighting of 108
REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED 111
Selenium as a Safety Apparatus 104

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

Common Commodities and Industries: Petroleum By Albert Lidgett. (Sir Isaac Pitman and Sons, Ltd., 1, Amen Corner, London, E.C. 2s. 6d net. pp. 168.)

THIS little booklet forms a valuable addition to the popular series on "Common Commodities and Industries," issued by Sir Isaac Pitman and Sons, Ltd. After a brief account of the origin of petroleum the author provides an illustrated description of the chief oil fields of the world, and explains its production and transport.

We then pass on to the applications of petroleum, special attention being given to its use in combustion engines and the part it has played in the war—for example, as the motive agent of some of the latest battleships, such as the "Queen Elizabeth." Not the least interesting part of this chapter is the account of the enterprising steps taken to make good the cutting off of many of the customary sources of supply during the war. There is a brief chapter (which one would like to see somewhat extended in another edition) dealing with the use of petroleum for lighting and the book is completed by a survey of statistical data.

Lighting from Concealed Sources.

A VERY well arranged booklet under the above title has been issued by the National X-Ray Co., of Chicago. There are 246 pages, and eleven chapters dealing with different aspects of concealed lighting. A feature is the large number of photographs of lighting installations.

A special word of approval should be given to the chapter dealing with many diverse applications of concealed methods (in shops, factories and mills; for stage lighting, tennis courts, bowling alleys, etc.). The method adopted on certain pages of grouping together illustrations of typical fittings, photographs of installations, technical data, etc., is particularly happy. The flood-lighting section is also of great interest.

A chapter is devoted to the planning of installations, and the book is concluded by a series of definitions and miscellaneous data bearing on illumination.

NIGHT SITTINGS IN THE HOUSE OF COMMONS.

NEARLY ten years ago there appeared in this journal an account of past methods of lighting adopted in the House of Commons,* reference being made to the extreme reluctance with which the introduction of modern illuminants in place of candles was sanctioned. Sir Benjamin Stephenson and the Earl of Bessborough on one occasion returned the following answer to a request for the installation of modern illuminants: "Do what you like for the acoustics and ventilation, but take it as a fixed and settled point that candles remain!"

A contribution by Mr. J. G. Swift MacNeill to the *Pall Mall Gazette* for February 28th carries the history back a step further. It appears that even the introduction of candles was acquiesced in reluctantly. In the time of Charles II. the House met at 8 o'clock and rose at 12, the sitting being thus completed in the morning. Later 10 o'clock became the official time of meeting (which nominally continued until 1806, though the actual hour of meeting was almost invariably later). In the past debates conducted by artificial light were discountenanced as "not being consonant with the genius of the House." Thus James I. described the deliberations on the great Protestation of 1621 as irregular because they took place by candlelight, and in the reigns of James I. and Charles I. sitting until it was dark was so exceptional that candles could not be introduced except by the express order of the House.

At last, by a Standing Order of February 6th, 1717, it was ordered that "When the House or any Committee of the whole House shall be sitting and daylight be shut in, the Serjeant-at-Arms attending the House do take care that candles be brought in without any particular order for that purpose."

At the present time, of course, much of the business of the House is done at a late hour of night, though there is no doubt something to be said in favour of the former practice of carrying out the main portion of business in the earlier part of the day.

---

* *Illum. Eng.*, Lond., Vol. II., 1909, p. 665.

THE CANADIAN MISSION IN LONDON.

THE Canadian Mission, which has recently been established in London at 1, Regent Street, S.W.1, was constituted by an Order of the Canadian Privy Council in November, 1918. The chairman is Mr. Lloyd Harris, who is a Canadian business man with a wide knowledge of the industries of Canada, and who has rendered invaluable services to the Dominion and the Allied cause as head of the Canadian War Mission in Washington.

It will be one of the first duties of the Mission to devise means of re-establishing the traditional trade between the Dominion and the Mother Country, which has suffered through the shortage of tonnage and the inevitable restrictions imposed during the war. It also hopes, by negotiations with the various Governments concerned, to promote the supply of goods for reconstruction work in the devastated areas. Of special importance in this connection is the supply of food, of which Canada has large supplies which she is willing to place at the disposal of Europe. Canada is also in a position to render aid in connection with the supply of agricultural machinery, of which she has made a speciality, while she has also available for export a great variety of other goods, including paper and pulp, lumber, hides, aluminium, asbestos, furs and clothing, many minerals, etc.

Canada seeks above all things to develop a larger interchange of trade with all parts of the Empire, and has large markets to offer British manufacturers. The Mission will at all times be willing to advise persons in the United Kingdom desirous of obtaining information on Canadian trade.

There is doubtless an important field for the energies of any body capable of developing common trade relations between the Colonies and Dominions and the Mother Country, and we wish the Mission success in the work it has undertaken.

·ELECTRICITY· ·ACETYLENE·
The
ILLUMINATING
ENGINEER
·OIL· ·GAS·
Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

The Arts of Stage Lighting.

The paper on the above subject read by Mr. J. B. Fagan, of the Royal Court Theatre, before the Illuminating Engineering Society on April 8th, opened up a new field for inquiry. The fascinating subject of stage lighting might be considered by some as falling somewhat out of the beaten track of the illuminating engineer. It constitutes a problem in which purely engineering details often play a subordinate part, and where the creative imagination of the artist is often the dominating factor. The Society accordingly invited the co-operation at this meeting of prominent stage producers and experts and the members of the Critics' Circle of the Institute of Journalists. Their experience was most helpful in throwing light on the various problems presented.

Mr. Fagan dealt with his subject in a most suggestive way, tracing the development of the art of stage lighting from its early beginnings as well as discussing present-day problems. His suggestions were such as to appeal to the illuminating engineer. He pointed out that in stage lighting the influence of tradition played a great part. In some cases the methods of using the lights are not far removed from those prevailing in the old days when only candles were available. Yet the range of illuminants and the devices for distributing their light are constantly undergoing improvement, and during the past ten years especially much useful information has been gained as to the possibilities of diffusing this light or modifying its colour by adjacent surfaces. Here, therefore, is a field in which the lighting engineer should be able to do good service by suggesting methods by which the ideals of the artist and the theatrical producer can be complied with. These ideals are largely concerned with the correct gradation of light and colour and the production of desirable shadow effects. Mr. Fagan strongly advocated the use of diffusing methods, by which the glare of bright sources can be diminished, and soft shadows, approaching more closely those obtained with daylight, reproduced. The ideal method for the purpose, he suggested, was the Fortuny system, which utilises what is in effect an artificial sky, permitting beautifully soft and gradual transitions of light and colour. A complete system of this kind, however, practically entails a specially designed stage. Mr. Fagan has sought to produce similar effects by the methods described in his paper (see pp. 118—125), and he invited suggestions from members of the Society as to how the required conditions might be most easily met.

The discussion also led to the raising of some other interesting general points in connection with stage lighting. For example, it was suggested that possibly for many productions an unduly elaborate system of lighting may be undesirable from the dramatic standpoint, because it would distract attention from the main feature of the performance—the actor's spoken words. We think, however, that the correct view, expressed by several speakers, was that *bad* lighting produces this distracting effect, being out of harmony with the conception of the play. Good lighting should be unobtrusive ; it should serve to supplement the idea of the drama and provide the right atmosphere for the spoken word, thus assisting the actor and in no wise distracting attention from his efforts.

The question was also raised whether it was desirable to leave the auditorium in complete darkness, as is commonly done. No doubt the stage should be most brightly lighted so as to be the centre of interest, but a moderate general illumination in the auditorium might not be prejudicial to the play and would be conducive to the comfort of the audience. Seeing that the provision of a weak general illumination is now becoming general in cinema theatres, where there is the special difficulty to be guarded against that such extraneous illumination may affect the definition of the picture on the screen, the matter seems worth consideration in ordinary theatres. One point that deserves notice is the importance of securing the co-operation of the illuminating engineer at an early stage in the planning of performances. When a company takes a production on tour, and the performance is given successively in theatres in different towns, the time available for devising and fitting up lighting appliances is sometimes unavoidably short. But when a long series of performances is to be given at one theatre there is no reason why the lighting effects should not be dealt with at an early stage. Otherwise it is difficult for the lighting expert to secure the best effect.

There are many other technicalities in stage lighting which remain to be considered. The whole question might well be studied by a small committee on which the Illuminating Engineering Society and other experts on stage-productions should be represented, and it is the intention of the Society to deal further with the subject in this way.

Standards for Gas on a Heat-Energy Basis.

Before the outbreak of war the question of rating gas on a calorific (*i.e.* heat-energy) basis was already being seriously considered, and the events of the past four years, during which gas was denuded of some of its constituents in order to furnish munitions of war, have emphasised the importance of the matter. The whole question is surveyed in the recent report of the Fuel Research Board, which was issued on April 23rd.*

Briefly it proposes that gas should be sold on the basis of heat-energy, but as it is not yet established that one B.Th.U. is in all circumstances of equal value it is stipulated that consumers' appliances for lighting, heating, and cooking should be properly adjusted by the company for the correct use of the grade of gas supplied. Thus each gas undertaking may decide on the calorific value it proposes to supply, and has the obligation of adjusting consumers' burners and appliances accordingly. It would, however, clearly be injudicious to have a great variety of calorific values in use, and it is therefore proposed that four standards—namely, 400, 433, 466 and 500 B.Th.U.—should be the limit. Naturally a company would aim at selecting from these grades one adapted to the requirements of its district and in some cases may even provide alternative supplies. Other recommendations are that the minimum pressure of gas at the consumer's meters should be 2 in. of water, and that the gas should not contain more than 12 per cent. of inert constituents, besides being free from sulphur compounds. In practice the charge made to a consumer would take into account both the number of cubic feet consumed and the number of B.Th.U.s per cubic foot.

The proposals constitute a most important departure and in several respects they reflect the light of experience. Thus the recognition of the need for adjustment of the consumers' appliances to suit the gas supplied is a natural development of the principle, now advocated by all the foremost and most enterprising companies, that it is their duty not merely to supply gas, but to aid the consumer in making the best use of it. Again, the limiting of calorific power to only four grades seems a very judicious step, bearing in mind the inconvenience which has been experienced in the electrical industry through the multiplication of different voltages. Agreement on this point should greatly simplify the design of burners, and even, in some areas, render the provision of adjusting devices unnecessary.

We observe also the recognition, in paragraph 48 of the Report, that while, for the purposes of conveying heat-energy, gas has many advantages, in the field of lighting and power both gas and electricity will share the work. This bears out the conviction we have recently expressed, that in the lighting field there is ample room for both illuminants. No doubt the reconstruction measures which may be expected to follow in the field of electricity will also have the effect of bringing about greater uniformity, especially as regards voltage of supply, and will thus also tend to simplify the work of the illuminating engineer.

---

* Report to the Board of Trade by the Fuel Research Board on Gas Standards [Cmd. 108]; published by H.M. Stationery Office, Imperial House, Kingsway, London, W.C.2.

The Supply of Research Workers.

The *Journal of the British Science Guild* for April, 1919, contains some useful figures illustrating the need for still better encouragement of scientific and technical education. While encouragement may be drawn from the steps already taken for the development of scientific research, there is clearly still much to be done in order to make up the leeway of past years.

In the United Kingdom the number of full-time students at Universities and Higher Technical Institutions is only 6 per 10,000 of population, as compared with 10 in the United States and 14 in Germany, though Scotland has the creditable value of 17 per 10,000 of population. These figures relate to 1913-14, and have therefore been presumably reduced still further during the war. Our aim now must be to look ahead to the future and ensure that sound foundations are truly laid.

One of our first needs would seem to be a clear and definite record of the progress of education in this country from its initial stages to the university, showing what proportion of the population receives adequate scientific and technical training. The data presented in the Report before us afford some indication on this point. Thus the number of students graduating with first- or second-class honours in science or technology before the war was only about 530. In 1913-14, 4,400 male students (excluding those taking medical courses) entered universities or leading colleges in England and Wales, of whom about half were from the public schools. Of youths leaving such schools after the age of 16 (about 5,200 annually) 25—30 per cent. enter the universities. As regards State-aided secondary schools, about 8,800 (forming about seven per cent. of those entering such schools) leave after the age of 16 years, and of these probably not more than twelve per cent. enter the universities.

Making a very rough estimate from the data available it would appear that of children entering State-aided schools, less than one per cent. enter the universities. We should, however, like to see fuller information prepared, namely data, presented in the form of a diagram showing :—

(A) The number of children entering respectively elementary and preparatory schools in any year.

(B) The number leaving school after 14 years, and also after 16 years.

(C) The number entering universities or colleges of standing.

(D) The number obtaining first- or second-class honours degrees ; and

(E) A statement of the proportion of these who take first- or second-class honours in science and engineering.

These data should be separated so as to show the proportion of education provided at public and private expense and should be prepared for this and other countries so as to enable a general comparison to be made.

We believe it will be found that in those countries where educational facilities have been provided for some time mainly by the State the proportion of children who can afford to continue their education at the universities is correspondingly great. The expenditure in this direction is well repaid, for where the general standard of education is high we find a population much more efficient, more prosperous and better fitted to take a wider view of social and national problems than where a large proportion is relatively illiterate, and unaware of developments taking place elsewhere.

LEON GASTER.

TRANSACTIONS
OF
The Illuminating Engineering Society
(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE ART OF STAGE LIGHTING.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, April 8th, 1919.)

A MEETING of the Society took place at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.), at 8 p.m. on Tuesday, April 8th, THE PRESIDENT (Mr. A. P. TROTTER) in the chair. The meeting was arranged with the co-operation of the Critics' Circle of the Institute of Journalists.

The Minutes of the last meeting having been read the HON. SECRETARY read out the names of the following applicants for membership :—

Member of Council :—

Story, Dr. J. B.	President of the Ophthalmological Society, 6. Merrion Square, Dublin.

Ordinary Members :—

Cassie, G. J.	Engineer, Messrs. Heatley and Gresham, Ltd., 110, Cannon Street, London, E.C.
Cole, H W	Stearn Electric Lamp Co., Ltd., 47, Victoria Street, S.W.
Elvy, J. C.	Electrical Engineer, "Gowansleigh," Rickmansworth Road, Watford.
Marx, E. A.	Pope's Electric Lamp Co., Ltd., Hythe Road. Willesden.

The HON. SECRETARY also read out again the names of applicants announced at the last meeting on February 25th, who were formally declared members.*

THE PRESIDENT then called upon Mr. J. B. FAGAN, of the Royal Court Theatre, to read his paper on, "**The Art of Stage Lighting.**" An interesting discussion ensued in which the following took part : Mr. WILLIAM ARCHER (Critics' Circle), Mr. T. J. DIGBY, Mr. G. E. MORISON (Critics' Circle), Mr. N. R. BOOTH, Mrs. K. SEARLE (Critics' Circle), Mr. N. MACDERMOTT (Everyman Theatre), Mr. J. W. T. WALSH, Mr. R. P. HOWGRAVE GRAHAM, Mr. LANE CRAWFORD (Britannia Theatre), Mr. W. G. RAFFÉ, Mr. J. DARCH and THE PRESIDENT. A cordial vote of thanks to Mr. FAGAN for his paper terminated the proceedings.

---

* ILLUM. ENG., March, 1919, p. 57.

THE ART OF STAGE LIGHTING.

By J. B. FAGAN (Royal Court Theatre).

(Paper read before the Illuminating Engineering Society at the meeting held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Tuesday, April 8th, 1919.)

I ACCEPTED the invitation of Mr. Gaster to read a paper before the Society on the above subject with some diffidence, as I do not profess to be an expert on lighting. I hope, however, that the discussion will elicit some useful suggestions. I may add that I have not seen a single stage in this country which in my opinion was properly lighted, and although I have for many years been making somewhat crude experiments with a model stage, on which I have a system of lighting installed, and during the past year have been testing the value of this system in our productions at the Court Theatre, I am the first to realise what a long way we have still to go before we get the perfect lighting which we see in nature, and represented in the art of painting, and which I conceive it is fully within the power of the science of electrical illumination to reproduce.

I know, of course, that there are many managers and producers who think that their stages are perfectly lighted, and a great many more who, if they ever think of lighting, regard it merely as a question of the amount of light necessary to see everything on the stage.

I remember one provincial manager writing to me that he had the best lighted stage in the country, and I discovered afterward that he made this claim because he had an unbelievable number of electric bulbs installed on his stage. The result of such lighting was, of course, merely the supervisibility of ugliness.

The importance of proper stage lighting can scarcely be over-estimated. I have more than twenty-five years' experience as actor, writer of plays, and producer of plays, and if I were asked what place I assigned to stage lighting in the scheme of dramatic representation, I should say that the relative values are as follows:—*First*, the play; *second*, the acting; *third*, the lighting; *fourth*, the scenery; and *fifth*, the dresses.

I do not think it is an exaggeration to say that it is in the third of these that the English theatre fails most signally. I have seen some very bad lighting in America, but they have some theatres where the lighting is better than anything we have to show. The same is true of France and Italy in a lesser degree. But in Germany stage lighting is head and shoulders above the rest of the world. This is a fact that might make us think.

The drama on its visual side is artistically something of a freak, a sort of bastard offspring of the art of painting and the art of sculpture.

One of the tasks of the theatre to-day is to legitimatise the child, and if this task is ever to be accomplished I believe it will be done by means of the magic of lighting.

Someone has defined painting as the art of representing light. I think we might define stage lighting as the art of placing, of graduating, and of colouring light—*and shade*; for light without shade is lifeless and uninteresting, and it is in the absence of shadow (natural and significant shadow) rather than in the presence of light, that our stage lighting most conspicuously fails.

I should like to treat the question of stage lighting from three distinct points of view—the historical, the psychological, and the technical.

It is not an easy matter to attempt to trace the history of stage lighting, and I do not know that anyone has yet made the attempt, but of course, like everything else in the world, it has a long history reaching back to the origins of the drama, and beyond to the origin of those origins hidden in the mists, which hang about the threshold of the record of human progress.

The art of the theatre, like all the other arts, had its beginnings in the religious aspirations of man. Art and religion were born almost together, but I think it would be true to say that religion was the elder of the twins, that the longing for a protective power and the desire to worship it preceded the imitative faculty which set the gods in wood and stone before the eyes of men.

If we care, therefore, to go back far enough we may trace the origin of stage lighting to the groves of primeval forests, to the play of sunlight through the trees in the day, to the strange patterns woven of light and dark, by the moon or by torches and fires in the night, and to the emotional effect this produced on the crowds of worshippers assembled before their gods. Accidental at first, this emotional effect of lighting must soon have become semi-conscious, and have lent itself to arrangement by the priests and magicians, and in that you have the beginnings of an art.

When the gods migrated from forest and cave to dwell in temples raised in their honour there can be little doubt that the priests carried with them some rudimentary ideas of lighting effects which under the more flexible agency of artificial lighting were capable of further development.

The evolution of religious ceremonial and dramatic representation are in the earlier stages so closely associated that it is difficult to disentangle them. But there came a period in the development of most religious systems when the drama, so to speak, threw off its sacerdotal vestments and came out into the open air.

The early stages of the development of drama have been practically identical in all civilisations. It begins under the cloak of religion in the open air, then it goes with religion into temple or church, then it breaks away from religion and comes again into the open air, then it builds a theatre for itself, at first a theatre open to the air, and finally makes its home in a closed theatre, when the history of stage lighting properly begins.

Historically the whole question of interior lighting is far too vast to deal with in this paper, and is outside its real scope, and so I shall confine myself to a brief summary of the rise of the drama here in England. It is worth while noticing, however, that as early as 750 A.D. the real value of lighting was fully appreciated, and that the cultivated classes in Byzantine Society were thoroughly alive to the possibilities of impressing their subjects, and the worshippers in the Churches, by means of resplendent lighting effects.

A contemporary historian remarks that the Hippodrome was illumined as bright as day for the races and representations, and Ambassadors to the Court of Theophilus the Great were amazed to see his throne a blaze of light, diffused from no visible source. It is certain that Byzantine engineers had great knowledge of the value of reflectors, and of naphtha gas as an illuminant, for dramatic representations, both spiritual and secular. Soon, however, inevitable retribution fell upon this highly organised but decadent empire, and the civilised world was again plunged into darkness. In England no form of dramatic representation existed at all prior to the Norman Conquest, the dramatic writers of classic times being utterly buried in the obscurity of early Christian prejudice. Artistic life was unknown, except to the clergy, who managed to keep a dim spark still flickering. It was from religion, however, that the impulse came which caused the drama once more to occupy the minds of the people. Certain French monks, viewing with alarm the utter ignorance of the people, began to search for some means of enlightenment, since the very rudiments of Christianity were but too poorly understood. In 1160 we find the first traces of dramatic representation in a crude miracle play, the "Festa Asinaria," and our first stage lighting in the sconces of candles that blazed before some shrine.

Very soon we find a whole series of miracle plays and mysteries being performed either just within the churches, or just outside on a kind of rough stage or scaffold. The proceedings somewhat resembled our modern Pleasant Sunday Afternoon movement. As the plays increased in popularity it became evident that the drama would fall into the hands of the laity, and the scene of dramatic activity was removed to the market place. Soon the country was filled with an increasing procession of crude travelling theatres playing whole cycles of religious dramas. The lighting of these stages was, of course, daylight, but at the beginning of the 15th century we find traces of flares and squibs being employed to give local colour to the devils. This is an important step in the history of lighting as it marks the difference between lighting for the purposes of illumination only and lighting as a psychological influence. In the British Museum there is a copy of an early miracle play, which contains a list of everything required for its representation

The process of secularisation was extremely rapid, but it was not until 1556 that Edward VI. granted his players a definite structure in which to produce plays. These players met with many setbacks, but a precedent had been set and half a century saw the birth of the whole structure of the Elizabethan theatre. A whole crop of theatres and dramatic authors sprang up, "The Theatre" in Shoreditch, "The Curtain," "The Fortune," and "The Globe," where Shakespeare first saw daylight, being amongst the most celebrated of the former. These theatres were circular in construction and open to the sky, the stage occupying the centre and backing on to one wall, fitted with doors and an overhead gallery. I can only find one doubtful trace of artificial illumination. Certainly artificial lighting as the *sine qua non* of dramatic representation was generally unknown in England till 1682, when Sir Christopher Wren built the first theatre at Drury Lane, and Inigo Jones contrived the stage mechanisms, withdrawing the stage from the centre and introducing the proscenium arch. A glass roof was built to the theatre, but this proved inadequate to light it, and shortly afterwards we find both stage and auditorium illuminated by sconces of candles, and performances being given in the evening. The stage was lit by two or more hanging corona containing about 30 candles each. This method lasted right through that period known vaguely as the Restoration. The next step forward occurred in 1755, when Garrick introduced footlights in the shape of rows of candles placed below and in front of the stage and masked by metal screens.

Here, then, we have a stage as we see it to-day, only lit entirely by candles. The demand for increased light brought about an invention of a "patent stage lamp" in 1785. Little is known of it, but that it was "marvellous brilliant," and it may perhaps have been responsible for the astonishing epidemic of theatre fires that occurred at the beginning of the 18th century. Anyhow the secret was so carefully guarded that it died with its anonymous inventor.

Stage lighting, naturally enough, had then no other object than that of illuminating the players, the artistic value of lighting was still to be evolved, nor is such an omission to be wondered at when the only medium of light was a tallow candle.

It is not until the introduction of coal-gas and the oxygen cylinder limelight that we find any real and serious effort made to co-ordinate the lighting with the rest of the performance.

It is well to bear in mind that till more or less recently the medium of gas has indeed been of greater utility than electricity in that it was under a far greater degree of control, being easily checked by a central tap.

Sir Henry Irving and Augustus Harris both worked ceaselessly for effects of light, and the results at the Lyceum Theatre were, comparatively speaking, magnificent; and it is due to their efforts largely that the æsthetic value of lighting came to be appreciated in this country. The invention of various methods of controlling electric current soon made electricity as a medium for lighting, with its almost limitless possibilities, quickly supersede gas, and to-day we think in terms of electricity when tackling the problem.

This, then, is briefly the history of stage lighting in England. We must observe that hitherto lighting has been used almost exclusively as a medium of illumination, and not as the artist uses his colours on his canvas for the purpose of creating a certain psychic condition on his public. In short, lighting has been a craft and not an art. To-day we must face it as both at once. Perhaps overmuch is expected from the theatre producer. He must have technical electrical knowledge, knowledge of painting and sculpture, of which stage decoration is the uncouth child, and lastly knowledge of psychology. The artist has no need of a scientific education to feel the acute psychic effect produced by gradations of colour and light. He has only to have walked amongst the great masters of painting to have experienced the amazing thrill which is so readily produced by the effects of light and shade in the later Dutch School. The value of this has been felt by the theatre producer, but his hands have been tied by difficulties, technical and otherwise, that surround him. The stage has developed along the same lines that have acted and re-acted upon the other arts until it has become the sensitive syntho-æsthetic product it now is, borrowing something from all the arts, moulding them into a single form of expression. Pre-Raphaelite painting is devoted almost entirely to the perfection of form, and lacks the emotional power that Raphael and his successors introduced. The same may be said of the early musicians, such as Vittoria and Palestrina. This we can say, without in any way disparaging the intellectual beauty of their work. Art in all its branches is tending more and more to plasticity and abstraction, as opposed to rigidity and symbolism. The art of the theatre has become the synthesis of the other arts, and as the drama has evolved from the mere representation of literature to a definite syntho-æsthetic craft, so do the difficulties in presentation increase, the chief of which is lighting, that is, of painting the rigid outline of scenic form and reducing it to plasticity. Furthermore, the hall mark of scientific approval has been placed upon the contention that artists have even held that colour, especially intensified, and following a definite scheme, has an incalculable effect upon the sub-conscious mind of the recipient. A sudden shaft of light may be as sinister as the blare of muffled trumpets or as beautiful as the sweep of stringed instruments. It is evident that if the theatre is to retain its place among the fine arts, we theatre producers cannot afford to neglect this most important medium of expression. Without perfect lighting, perfect harmony is lost as much as it would be were the leading note of a Mozart sonata reiterated half a tone flat. It is to you, therefore, who are experts in the science of electrical illumination that we must look for skilled aid in the difficulties which beset us, for we have not the time to acquire that full knowledge of optics and mechanical contrivances that the situation demands; hence the innumerable and often clumsy attempts which have been made in recent years towards improvement. The question of lighting must also be considered from the point of view of the actor, who, after all, is the life that pervades the whole. He demands perfect harmony in his surroundings and decorations, even as a singer demands it from the orchestra of which he forms part. The actor is the life, the human body, plastic and mobile, and he is in intimate relations with the inanimate. The movement of the human body demands obstacles by which to express itself, and all artists know that the beauty of bodily movement depends on the *points d'appui* which are afforded by zones of light.

I shall now endeavour, with no little diffidence, in the presence of so many experts, to touch upon the technical side of the question.

In the ordinary theatre of to-day, either through the ignorance of the owner or his lack of initiative, electricity is employed on exactly the same principle that governed the use of candles in 1775 and gas in 1880, and on consideration, I think you will agree with me that this method tends to destroy artistic plasticity even more than the antiquated candle, for the faults of the candle are increased by the higher intensity of the electric power. There are four principal methods of placing light.

(1) The overhead batten, that is, a series of coloured or plain bulbs placed among the borders that mask the top of the scene, about twenty feet above the actor's head. The principal function of these is to illuminate painted scenery. These battens are reinforced by movable lengths, which are hung on wings or laid on the floor of the stage.

(2) The footlights, which are intended to illuminate the actors from in front and from below.

(3) Standard arc-lights, movable or raised high up on the interior edge of the proscenium arch. These are either left open or coloured and frosted at will by means of gelatine mediums.

(4) The placing of bunches of bulbs behind a transparency.

It will be easily seen that the shadows cast by such an arrangement of light destroy the naturalness and ease of the actor. Fifty open lights cast fifty distinct shadows, and no amount of pick-up lights can obviate this. The battens that should illuminate the scenery, illuminate it in unnatural streaks, casting hard lines that must jar upon the artistic susceptibilities of both players and audience. The brilliant direct rays of unprotected arc lights, especially when intensified by a lens, are hard, unnatural, and grotesque, and absolutely destructive of artistic plasticity.

The fault lies primarily in the placing of these lights, and secondly in the lack of diffusion.

Nature has two means of lighting, the direct rays of the sun that fall in parallel lines, and the light of the sky, which is everywhere diffused. These two forms of light used together, or diffused light by itself, can illuminate space, but direct light alone cannot do this.

For the lighting of an outdoor sky this old-fashioned method has failed utterly. The batten, coloured blue, lights a small section overhead, the rest of the light being supplied by standard arcs with or without a coloured gelatine medium. Of course, a large section of the sky is left entirely in darkness, and such light as there is, is streaky and unlovely. The placing of lights and their radiation of large tracts with coloured and diffused light, are two of the chief difficulties for the overcoming of which we turn to the expert for help.

Several modern producers, realising the futility of trying to give anything really beautiful under such circumstances, have turned their attention to overcoming these difficulties.

Mr. Gordon Craig introduced some 15 or more years ago a lighting system in which all light was thrown from the grid high above the actors' heads by means of inverted arcs. This system certainly did produce some very beautiful effects of light and shade, but as the light was entirely on the floor and on the upper portions of the scenery, and the shade principally on the faces of the actors, the experiment was a failure, though its author was perfectly satisfied, as I believe it is one of his curious theories that the actor's face is at all times better unseen. I do not wish you to think that it is my intention to disparage the work which Mr. Gordon Craig has done for the theatre, quite the contrary. Gordon Craig is a genius gifted with such a plethora of irritating eccentricities that they have almost obscured the epoch-making results which his work has produced.

The epoch-making results have occurred, it is true, principally in Germany; the English theatre has seen little of them as yet. But I am afraid there is nothing new in that fact; we have only to remember the case of aniline dyes, of how many other products of English genius which have been cast forth from their native soil for the laborious German to adopt and develop and make his own.

Gordon Craig, regarded as impracticable and intolerant, was laughed at by the men of the theatre in this country, and his ideas had almost no direct effect on our stage, yet all the great German producers, from Rheinhart downwards, have been working mainly, if not wholly, along the lines originated by Gordon Craig.

It was his production of Hamlet that vitalised the Moscow Art Theatre; it was the exhibition of his scene designs which stimulated stage reform all over Europe and America.

Gordon Craig has produced few plays (fortunately, perhaps, for his methods of production would destroy the dramatist and obliterate the actor); he has invented no system of lighting which can be used with advantage—and most of his scene designs are unrealisable on the stage (if you scale his drawings, you will find he requires a proscenium opening 120 feet high, whereas the average height in theatres is 20 to 25 feet).

Yet, in spite of all this, when the perfectly synthesised art of dramatic representation is finally evolved, it will derive directly from Gordon Craig.

There is one system of lighting which gives almost perfect lighting effects, that is the system invented by Mr. Mariano Fortuny, which has achieved a well-deserved and world-wide reputation. The chief difficulty attending this system is that it is nearly impossible to fit it in an old-fashioned theatre, as it needs large tracts of open space which few theatres can afford. It is also very costly in installation and costly to run. To explain it in detail would take too long, and need the aid of diagrams. But, to put it shortly, it depends on the use of reflected instead of direct light. Instead of lighting the stage with incandescent bulbs tinted in crude colours, the Fortuny method throws its brilliant illumination away from the stage against bands of coloured silk, which reflect the light in any colour or tint desired, either upon the whole stage or upon a selected part of it.

This light is strictly diffused, since it casts no shadow of the object it illuminates. Such is the basis of the Fortuny system, and the results obtained are extremely beautiful, since slow gradations of light can be used and colours mixed on the reflecting screen, just as an artist mixes the colours on his palette.

Escape of reflex light is guarded against by the use of black velvet, which has a refractory value of only 2 per cent. Of special beauty is this system when used in conjunction with the Fortuny firmament or heaven, of which there exist three or four patterns. The most simple is a lathe and plaster, semi-circular wall, painted an azure blue, and stretching from the floor of the stage, well above the line of sight from the auditorium. Pin holes, illumined by electricity, can be used to give a star-lit effect, and the whole is bathed in diffused light by a series of reflecting screens. It would be an attractive task to enter into the detail of this system, but I want to point out immediately the objections to it that meet us in the practical field.

(1) The impossibility of installation in all but specially designed theatres.

(2) The waste of illuminating power due to reflection.

(3) The high cost of maintenance.

At the Court Theatre I have endeavoured to achieve the softness and diffusion of the Fortuny system by a very much less complex system of what I might call semi-direct light. This system is the result of experiments extending over a number of years which I carried out on a model stage.

Immediately on the stage side of the proscenium arch I have constructed a bridge stretching from side to side on which I have placed four enclosed half-watt lamps of 1,000 candlepower each, tilted at an angle of about 45 degrees, coloured by gelatine mediums and rendered semi-direct by frosted glass screens. These lights and two further perch lights are under resistance, and by the variation of the mediums enables us to mix colour with almost as great a facility as the Fortuny screen. We have not as yet been able to dispense with the footlights. These are however indirect. Concealed bulbs lie in the old trough for the footlights, but lengthways. The direct rays are hidden from the stage by a zinc screen, but a carefully painted reflector gives a very gentle diffused amber light that effectually picks up the slight shadow that is still cast by the overhead semi-direct lanterns.

In place of the Fortuny firmament I have a large semi-circular cloth, painted azure up high, but shading to grey about 6 feet above the stage level. The perfect illumination of this cloth has always proved a considerable difficulty. At present we have lanterns fitted with 1,000 candlepower half-watt lights, similar in pattern to the bridge lights, but tilted at various angles to ensure the complete illumination of the panorama cloth. On the stage we have similarly constructed semi-direct standard lights, which pick up the light where the overhead lighting finishes. I think I may say that this is an advance, but as yet by no means perfect. As yet I have found it difficult to throw gradual changes and gradations of intensity for such effects as gradual sunrise or sunset or heavy rain clouds. The perpetual mobility of these effects is most difficult to produce, except by means of the Fortuny "palette," or an elaborately painted transparency — a garish and unconvincing expedient. Neither is it possible that the colour can be absolutely smoothly laid on when emanating from four or six different sources.

I hope that I have succeeded in convincing those of you who were not aware of it that the art of stage lighting is assuming an importance second to none, and that there is a wide field for research and ingenuity for the skilled engineer who is also an artist.

One great producer, Mr. Granville Barker, who, before the war, gave London a number of remarkably fine productions, failed, it seemed to me, completely in his lighting because he refused, except on very rare occasions, to employ coloured light. He seemed to be always trying to capture in the theatre the white light of day, and to have said to himself that tinted light is unnatural.

But the white light of day is not to be captured, and its imitation is cold and anæmic. Besides, daylight takes on the colour mood of its surroundings, only in the ether is it pure white, and tinted light is the only means we have of reproducing this in the theatre, as we have no illuminant powerful enough to re-colour the atmosphere by refraction.

Therefore, though tinted light be unnatural, the effect of its use in the theatre is both natural and beautiful. All art is unnatural, and nature is not always beautiful.

So the stage lighting artist, like the painter, must go to nature in her softer moods, and select those which harmonise best with his subjects; he must change with the emotional changes of the play, melting one mood into another. The day is not far off when we shall see the electrician an artist as well as a technical expert, seated at his switchboard like a player at an organ, sending forth rhythmic harmonies of light that shall be as music to the eyes, swaying strange sub-conscious moods in the audience, in perfect tune with the unfolding of the drama in which he himself is playing a part of no mean importance.

DISCUSSION.

Mr. **William Archer** thanked the author for his most suggestive paper. Discussing a few points raised in the paper, he said it was not at all clear that stage illumination did not begin until 1680, as was suggested. That there must have been some illumination before that he thought was fairly certain, even if it was only by torches. In the winter the plays began at about 2 o'clock, and lasted for about two hours, and probably ran into the third hour. It must often have been quite dark before they finished, and there must, therefore, have been some means of lighting. In the private, or roofed, theatres, there certainly could not have been sufficient natural light through the scanty windows with which theatres of those days were fitted. Again, though most of the Elizabethan performances doubtless took place in daylight, there must have been some means of indicating darkness, and he often wondered whether that was done by sending some one on to the stage with a candle or a torch. It was commonly stated, as the author had done, that Garrick introduced footlights from Italy; but there was a plate in existence, dated 1660, wrongly described as the Red Bull Theatre, which showed perfectly clear footlights in half a dozen sconces. Footlights seemed to have disappeared soon afterwards, however, because at the end of the 17th century and the early part of the 18th there were no footlights. Mr. Fagan had suggested that in Garrick's Theatre the light was used for nothing but to illuminate the faces of the actors. At that time there was a very remarkable scene painter, Loutherburg, who worked for Garrick's Theatre, and it seemed incredible to him that this artist should not have arranged the lighting to do justice to his work. The theatre which the late Prof. Herkomer built at Bushey, the Little Theatre, was a curious pioneer theatre in the matter of lighting, and to a considerable extent it anticipated the Fortuny system. In that theatre there was a standing background of sky, and there was a very wonderful moon. It was an absolutely perfect moon (the face photographically reproduced) which by concealed clockwork mechanism moved gradually over the scene. Whether it was worth doing was another matter. It introduced the question whether the audience, watching that moon, would have their attention taken away from the actors. Herkomer was anxious to produce natural effects, and he remembered that he showed a cornfield painted which had the shocks of corn cut in relief to cast their own shadows. The author had paid a tribute to Gordon Craig, which was very well deserved. Gordon Craig had done a great deal to advance the art of stage lighting. He was engaged at the Deutsches Theater in Berlin, under Rheinhardt's management, but his ideas were too impracticable, and he was too obstinate and uncompromising in his views to retain that position long. In fact, he did not think he ever really produced anything there. He had, however, seen several productions at the Deutsches Theater, and was perfectly sure that they had picked Gordon Craig's brains and used his ideas. He did not think Gordon Craig vitalised the Moscow Art Theatre, as the author had said. He went there to produce "Hamlet," which was rehearsed for something like a year; but the theatre had done a great deal of artistic work before Gordon Craig's production of "Hamlet." It was his own opinion that the modern actor attached far too much importance to having the limelight upon him. There were many scenes of twilight in which the actors' faces were not seen and yet the play did not lose anything thereby. It was one of the illusions of the actor that visual expression was the first thing in his art. The voice was the first thing; facial play came only second. With regard to the use of electric light in the auditorium, he could never understand why the auditorium should always be plunged into utter darkness. It was not only very inconvenient, but it unduly emphasised the artificiality of the stage lighting. The question of stage lighting, of course, referred very much more to exterior than interior lighting. He personally did not think the interior lighting of the average stage was at all bad. It was in connection with the exterior lighting of the stage that modern methods would play an important part in the future.

Mr. THOMAS J. DIGBY remarked that it not infrequently happened that the illuminating engineer was only called in for consultation at the very last minute, when it was difficult to make any important modifications in the stage lighting. The design of the theatre had also an important influence on the lighting conditions. Theatres were not always used for the purpose for which they were originally intended. They might have a comedy one month and a drama the next, and in such circumstances at was difficult to secure really satisfactory lighting effects. The illuminating engineer should be consulted, jointly with the architect, at the very commencement, so that a comprehensive and adequate scheme of lighting could be worked out initially. Something had been said regarding the better lighting alleged to be provided in German theatres, which he had closely studied in 1902. He found that the chief feature was the degree of standardisation, little difference existing between one theatre and another. Generally speaking there was little attempt to adapt the lighting to the requirements of a particular theatre and the fine gradation of lighting possible in some of our theatres was not provided. The German system showed a lack of flexibility, a disadvantage which militated against really fine effects, and rendered impracticable some of the systems which had been proposed during the past five years.

Mr. G. E. MORRISON (*Chairman of the "Critics Circle"*) also expressed his admiration of the paper. He agreed with Mr. Archer that there must have been a great deal more lighting in the very early days than there was evidence of. If they took Shakespeare, for instance, one of the places in which these plays were acted was in the Middle Temple Hall which was still standing. That Hall was not well lighted naturally and there must have been some special means of lighting adopted. Then there were the numerous masques at private halls which took place at night for which there must have been artificial lighting of some sort. Another point he would like to make was as regards people walking about on the stage. It had been proved that this often had the effect of taking the attention of the audience off the play. A case in point was the play "Daddy Longlegs," in which were some lines which it was thought ought to get a laugh, but which never did until the play was acted to the blind soldiers at St. Dunstan's. That was noted as a curious point, and on investigation it was found that when played at the Duke of York's Theatre there was always somebody moving about the stage at the time these lines were spoken. When this was avoided, the lines got the reception which it was always thought they should have had. This demonstrated the danger of distracting the attention of the audience by extraneous effects, including lighting. As to the light always being on the actors' faces, there were times when it was not desirable that the light should be on their faces. For instance, in "Cyrano," Mr. Loraine, who wore so monstrous a nose as to kill all facial expression, was most effective in the balcony and the death scenes, when there was not enough light to see his features. Speaking generally, a great deal more could be done than had been done hitherto.

Mr. N. R. **Booth** said that there were several fundamental principles which he had kept before him in his experience with stage lighting in the north of England. He thought that it would be agreed that the closer the agreement between the system of artificial lighting and daylight the better. The gas-filled lamp was of considerable assistance in this direction but unfortunately until recently it had only been obtainable in comparatively large candlepowers, which were not conducive to uniformity of lighting and involved undue concentration of light in certain directions. He had, however, been experimenting with gas-filled lamps of low candlepower and consumption, using a considerable number on each batten, with very satisfactory results.

On each batten there were installed four distinct circuits, comprising respectively white, delicate amber, blue and red lamps. Liquid resistances were used to produce gradation of intensity, and by blending these colours, beautiful effects, including the faithful representation of sunsets, could be secured. A few weeks previously he had worked the switchboard when they were representing a sunset, the duration of the effect being twenty-one minutes. The colours changed from white to rich red and then to ruby and the transition was accomplished so gradually that it was impossible to detect any abrupt change in colour. This was done by the aid of small gas-filled incandescent lamps and without the use of the "limelight"—a result which he believed had not been achieved before.

Mrs. K. **Searle** said that attention had been called to the danger of attention being distracted from the performance by undue emphasis of the lighting effects. She thought that this was less likely to occur when the lighting was carefully studied in order to produce suitable effects. It was much more likely that such distractions would be caused by bad lighting.

Mr. N. **McDermott** said that the credit for first taking up the matter of stage lighting belonged not to Gordon Craig, but to Adolph Appia, an Italian-Swiss. Gordon Craig's value to the theatre lay more in his theorising than in his scenic work or lighting. He had been experimenting with gas-filled lamps. In reference to Mr. Fagan's suggestion of tilting them he had proved that if that were done the filament sagged instead of remaining spiral, and the value of the lamp was gone. Another point was that the tremendous heat which these lamps gave off prevented their inclusion in a box or fitment with complete success. At the same time, he believed the gas-filled lamp had revolutionised stage lighting and it gave a means of perfect grading which did not exist with the arc, though the gradation was more sudden at the commencement than later in the drop.

Mr. J. W. T. **Walsh** agreed with the remark of Mr. Searle's as to bad lighting distracting the attention of the audience. Surely it was more likely that the attention of the audience would be more distracted by some obviously anomalous example of lighting than by a system in which everything was so perfect that it simply became a natural part of the whole scene, not calling for any conscious attention at all.

With regard to the tilting of the half-watt lamp, there did not seem to be any particular reason why this type of lamp should be tilted in any particular direction. The distribution round the ordinary half-watt lamp was uniform over a wide range and with the use of suitable reflectors it was possible to get any desired distribution of illumination. Trouble, however, might arise if the lamps were tilted over a wide range, and he did not see that there was any necessity for it. The question of dimming was, of course, a problem of resistance design, and it would probably be necessary to design them specially for the purpose in view. That should not present any considerable engineering difficulties.

Mr. HOWGRAVE GRAHAM also disagreed with the view that good lighting effects distracted the attention of the audience. If the lighting of all theatres was as near perfection as it was possible to make it, then the audience would gain by it without being distracted by its unusual character. With regard to dimming lights, there were difficulties in adjustable rheostats for this purpose. With an ordinary rheostat with uniform gradation of resistance per inch, a movement of, say, one-tenth of the whole length of the rheostat at one end causes a change of 10 per cent. in the resistance, whereas an equal movement at the other end means a 100 per cent. change. The illumination from the lamps used, however, varies with a high power of the applied voltage, and it should be quite easy on a mathematical basis to design rheostats so graded that the reduction of the candlepower at the source should be perfectly uniform and could be accelerated at any desirable moment between full brilliance and darkness.

Mr. W. G. RAFFÉ, F.S.A., A.R.C.A. (Lond.), said there were some distressing arrangements in use in regard to colour effects. Many ideas on the subject were fundamentally wrong and would have to be revised in the light of recent scientific research. He preferred lights shaded from the audience in the auditorium, and instanced the Æolian Hall, where this practice was followed. In some cases, however, there were bunches of lamps which were nearly in line with the eyes, as, for instance, the small Queen's Hall, and it was impossible to look towards the platform without inconvenience from them.

Attention should also be given to the framing of the proscenium, but in aiming at an appropriate setting care should be taken not to arrange it so that the attention of the audience was attracted to it. At the Scala Theatre the framing of the proscenium was in white and gilt, which looked nice when the lights were all on, but when they were out in the auditorium there were many little flickers coming from the gilt, and reflections of the stage-lights from the white which were very troublesome. In this respect something could be learned from the American cinemas, many of which had black velvet round the screen, which is of beads set in between glass. Possibly a *dark* velvet framing of the proscenium of a theatre would add to the effect in the same way as in the cinemas, by providing a suitable frame to the stage picture. Whistler allowed no frames to detract from due attention to his pictures, and by skilful framing he got a better effect from the enclosed canvas. The same psychological factor is involved in the theatre, and all devices should be used to concentrate attention on the stage, by removing all disturbing factors which may prevent this being accomplished.

Mr. LANE CRAWFORD remarked that there was little available literature on this subject; he had searched high and low for books on stage production, and had eventually found one which dealt with it to a small extent.

Mr. William Archer raised the question as to how "night" was represented in the early days of theatrical art. He had found a reference to this point in *Essai sur l'Histoire du Theatre*, by G. Bapst, who, speaking of the art of the mechanician in the French theatres of the 15th century, said that "smoke was used to imitate night and darkness."

Another point raised by Mr. Archer as to early methods of stage illumination might in some measure be met by the following extract from *The Theatre*, by Charles Hastings, relative to the Elizabethan Drama :—

"The private theatres, that is to say, the Cockpit, the Salisbury Court, the Blackfriars Theatre, were, unlike the others, entirely roofed in, and could thus be used in winter. The stage was then illuminated with candles. . . . The Globe, the Fortune, and the Red Bull were public, and as the house was open to weather the theatrical season, on account of the fogs, lasted only for two or three months ; this at any rate was the case for the Globe. The use of torches was of course unknown." He believed that Mr. Archer had already mentioned the probable use of torches for illumination.

It appeared that there was still much to be learned in regard to stage lighting. The difficulty was that of combining artistic effect with, at the same time keeping, the light on the actor's face. He did not think that there was much complaint to make about the lighting of interiors, although there was room for more shadow or a little atmosphere. Usually the area underneath the tables on a stage was lighted as brightly as the top, owing to the footlights. He often wondered why they adhered to the old-fashioned footlights.

He was not at all sure that it would not be better to try a suggestive effect in regard to the moon rather than to attempt to produce a real moon. In the present state of the art the moon occasionally had an awkward habit of going out. The representation of the sun and moon was important in stage effects and called for the co-operation of the scene painter and the illuminating engineer, as the scenes should surely be painted with some regard to the light that was to be used with them. The lighting of the auditorium during the performance was a matter for consideration which had not occurred to him before.

Mr. John Darch said that the aim in all stage lighting effects was to copy nature as nearly as possible, and he regarded the Fortuny system as the best for this purpose because it adopted the methods of nature. The producer of an open-air scene aimed at obtaining uniform, shadowless lighting, and in principle he was right ; but natural lighting was not uniform by any means, there was always a stronger light from one direction of the sky than from others and consequently there were shadows. People got so used to this effect that when they saw a person on the stage with the whole of his face equally illuminated they at once regarded it as flat and unnatural. He had encountered this difficulty in the lighting of a pulpit ; he had to throw a strong light on the preacher's face, but he took care to put a stronger light on one side than on the other, which gave a more natural effect. That was a point which the author might think of in connection with stage lighting. He had gone into the question of colours a great deal and they would find that green particularly would suffer with ordinary artificial light. He agreed with the author that too white a light was undesirable on the stage because it looked too blue, but that was only because we were so accustomed to yellow. White light was the light of day and if the public became more accustomed to white at night they would not think it so strange. Moreover, the scenery would then look more natural. If yellow light (as from the carbon filament lamp) was thrown on to scenery which was painted green it would appear nearly black, and mauves would go grey. He supposed it was the scene painter's duty to so colour his scenes as to meet any defects in the light, but in any such case it was very difficult to get true colour results. The white flame arc lamp, however, gave an absolutely perfect white light and the colours could by that means be got as perfect as in the open air ; but it was somewhat impracticable on a stage ; the "half watt" and other metal filament lamps were the most practicable and convenient. There was a much smaller preponderance of yellow in modern than in the earlier types of electric and other illuminants, but even this could be rectified. As the blue of the daylight spectrum neutralised the yellow to produce white, so either (1) a faint tint of cobalt blue in the glass bulb, or (2) the insertion of an occasional mercury vapour lamp would produce a light that would yield true colours from the scenery.

Mr. L. Gaster said that the meeting had been useful in collecting opinions in regard to stage lighting, a subject on which the available information was very meagre. It was necessary to obtain the views of experts of all kinds interested in stage lighting, and this had influenced the Council of the Society in inviting the Critics' Circle of the Institute of Journalists to participate in the meeting. He wished to thank Mr. Morrison, the Chairman of the Circle, and the other representatives present, for their co-operation in this matter.

The PRESIDENT said this subject had always interested him since electric lighting was first introduced to the stage, which was, he believed, at the Savoy Theatre in 1881. He had an opportunity as an electrical engineer of seeing the arrangements, and they were uncommonly well done from the first. Ten years later he was consulting engineer to a number of theatres, and it was extremely interesting work. It was chiefly from the point of view of economy that he was called in, for the cost of the lighting—that is to say the waste of misdirected lighting—was terrific. Enough current was used to light a small village. During the run of " La Cigale " at the Lyric there was trouble with the windmill which threw a shadow on the back cloth. With the more scientific methods now available new effects could be produced, especially as regards colours, but to obtain the best results there must be co-operation between the lighting engineer and the scene painter. It was no use, as had been said, for the lighting man to be brought in at the last moment. That was often done by architects who completed their designs and had the happy thought of bringing in the lighting man to do his best when it was in fact too late.

Mr. G. A. APPLEBEE (*communicated*) :—
In Mr. Fagan's most interesting address on " Stage Lighting," he has given us some useful details on the origin and advance of stage lighting.

In reference to the lighting of theatres in early days, I would like to mention that Mr. Dyce in his " Life of Shakespeare " tells us that public theatres at the time of Shakespeare's tenure of the Globe Theatre were illuminated as follows: " Cressets or large open lanterns served to illuminate the body of the house and two ample branches of a form similar to those now hung in churches gave light to the stage." I imagine this would be about the time when the Old Globe Theatre was built, in 1594.

I would like to ask Mr. Fagan if he could tell us how the footlights came to be known as " floats," as I have often seen them described as such, on some of the old gas lever plates or " gas box " as they were called. I am inclined to think that this stage " float " took the form of a trough containing oil in which cotton wicks, supported in suitable holders, were caused to float lighted on the oil, and thus provided the illuminant for the stage.

Mr. Fagan mentions the Lyceum Theatre, and the following extract from Mr. Theodore Tussaud's articles, which are appearing in the *Evening News* under the heading of " The Romance of Madame Tussauds," may be interesting : " Madam vacated the Lyceum Theatre, then known as the English Opera House, in 1803 in order that Mr. Winsor might make the experiment of lighting the place with gas. It was the first house of entertainment to be so lighted and the innovation was regarded as dangerous."

I was rather pleased to hear Sir Augustus Harris mentioned for his lighting effects at Drury Lane Theatre by gas and gas limes. It interested me very much because about that time (1883-6) I was very busy assisting Sir Augustus Harris in working out some of those effects. The knowledge I gained on stage lighting during this period has proved very useful. In those gas days at Drury Lane such a thing as a hard sharp shadow was unknown, partly by the great number of gas burners in the battens and footlights, and partly by the low power of the gas limes and the great distance they were from the object to be illuminated.

Whilst on the subject of gas I should like to mention that Miss Ellen Terry in her " Story of My Life " says :—

" We (Sir Henry Irving and Miss Terry) never had electricity installed at the Lyceum. When I saw the effect on the faces of the electric footlights, I entreated Irving to have the gas restored and he did. We used gas footlights and gas limes there until we left the theatre for good in 1902. To this I attribute much of the beauty of our lighting.

The thick softness of the gaslight gave illusion to many a scene which is now revealed in all its marked trashiness by electricity."

This view was also strongly held by Mr. Henry Emden, the scenic artist (for many years at Drury Lane). As regards the trashiness, he maintained that the heat rising from the gas created an atmosphere which gave the scene a certain amount of life, and from his point of view the electric light gave the painting a hard and cold appearance.

When Mr. Charles Harris, the brother of Sir Augustus Harris, went to the Old Gaiety Theatre as Stage Director in 1886, he held the same opinion and he had the electric footlights taken out and replaced by Argand gas burners. In justice to present-day electric installations I must confess that the said electric footlights were very crude.

In reference to some circular screens which would do away with back cloths and sky borders many ingenious designs have been tried. I remember at the Old Gaiety Theatre, in a burlesque called "Don Juan," Mr. J. T. Tanner, the producer, tried a screen consisting of pale blue gauze in different thicknesses, and stretching from above the proscenium describing a curve to the back of the stage and lashed at the sides of the stage to supporting irons, but the screen had to be lighted by battens and gas limes above it. This screen was used in an exterior scene and had to be struck for the change of scene which was an interior. Had more modern illuminants been available, I think this form of screen would have been more successful than it was.

There is no doubt whatever that the semi-circular dome-topped screen is ideal. But the surface of this dome should not be smooth but rough, as near a blotting paper finish as possible, and coloured a silver grey. Unfortunately this scheme is not practical for some theatres owing to want of space and the changing of scenes and also the type of play.

The use of high candlepower gas-filled lamps that Mr. Fagan has found so successful is subject to the design of the scene, by the scenic artist, and in many cases should be very effective, but the manner of manipulation is a great factor like any other kind of lighting. There is no reason why the stage arc lamps should not continue to hold a high place in stage lighting—of course, it means a well-designed lamp and use of effective screens. In a patent I brought out in 1908 I invented a screen, which consisted of a small sheet of specially treated mica placed inside the projector and fixed between the arc lamp carbons and the lens. I find this gives a good diffusion and there is no sharp shadow or hard circle of light. In some scenes the arc lamp has to do what any other type of lamp could not do and it must not be forgotten that shadows painted by the artist require as much lighting as the other parts of the scene.

On the subject of footlights and shadows much trouble is caused in many theatres by a sloping reflector made of polished wood or enamelled iron, which is sometimes painted white. This has the effect of throwing reflected light in the direction of the auditorium, and I have often seen ladies in private boxes using their fans to avoid the glare. With this design of footlights the bulb of the lamp is usually partly below the stage level, the result being a decided shadow, in some cases 3 feet high at 30 feet up stage. In cases like this the trouble is caused by the sight line from the stalls requiring the footlights' hood to be low to enable the floor of the stage to be seen by the occupants of the stalls. Therefore the rake of the stage and floor of the auditorium should be such that the footlights could be fitted without the sloping reflector.

Mr. Fagan's idea of reflected light in footlights should be very effective in many cases, such as exterior scenes where the footlights can be assisted by lights up stage, but for interiors the scenic artist should design his scene to enable a batten immediately in front and below the ceiling to assist the footlights. More attention should be paid to the use of frosted screens and lamps, especially when furniture, metal and glass which have highly polished surfaces are used. Stage furniture should have a matt surface to avoid the reflection from the footlights.

In many theatre orchestras the reflection from the sheets of music has a very disturbing effect on the audience, and this white glare coming between the stage and the audience in some cases is detrimental to the effects on the stage.

On the question of coloured lamps, the most artistic effects I have ever got were obtained by the use of lamps which were made of natural coloured glass and then sand blasted to obtain the frosted appearance. By this means the colouring was most delicate, beautiful and evenly diffused. But difficulties of getting the exact shade of colour required and the cost make this rather an expensive item.

The use or rather misuse of metal filament lamps on many stages without carefully blending and toning the light adequately to obtain the most artistic effect to suit the particular scene has the effect of giving the scenery and the costumes a washed-out appearance, which was not apparent in the days of the carbon filament lamp, and therefore in some theatres we have harsh crude lighting and prominent shadows.

The great art of stage lighting is to light a scene effectively without indicating where the light comes from (direction of stage sun and moon excepted). I am sorry to say that the opposite occurs in a good many theatres and gives Mr. Fagan the opportunity to calling the attention of illuminating engineers to the necessity of improvements in the system of lighting.

Mr. J. S. Dow (*communicated*): It must be owned that the early pioneers in stage lighting showed great ingenuity —illustrated, for example, by the gas-lighted artificial moon, which moved across the sky trailing the necessary tubing behind it. Mr. Bram Stoker, in the *Nineteenth Century*,* relates how Sir Henry Irving dimmed his gas lights by dragging sheets of silk across them. Most of the discussion has dealt with the lighting of objects on the stage; the production of special light-effects is a separate problem. Among such devices may be mentioned the production of sparks between the swords used in the duel in Faust (or on Vulcan's anvil), by the interruption of an electric circuit; the use of concealed ruby lamps behind a column of flowing water to simulate molten iron; the rotating diaphragms in front of projectors which serve to imitate rippling water, snow, hail and rain, etc.

In stage-lighting Mr. Fagan emphasises the value of diffusion. This is surely of importance to the actor as well as the audience. Fiction writers refer to "the glare of the footlights." But why should this glare be accepted as inevitable? It must distract the actor who is endeavouring to assume a certain posture or expression. One would be inclined to think that the spot-light or limelight would be open to a similar objection from the actor's standpoint; the expression of a brilliantly but obliquely lighted face is apt to be distorted, in addition to the fact of "make-up" being too clearly seen.

The view has been expressed that the lighting of interiors on the stage is usually adequate, but I recall cases in which the artificial illumination of a drawing room bore no relation to the illuminants provided. Thus it is absurd to see the servant lighting the candles in a room already brilliantly lighted by the conventional stage lighting; I recall one play in which the three main scenes occurred at different epochs, the room being accordingly lighted respectively by candles, gas lamps and electric lighting; but while the illuminant changed the conditions of illumination, for which the footlights were mainly responsible, remained much the same.

The difficulties to which Mr. Fagan refers, especially the attempt to eliminate footlights, have been dealt with in some of Mr. Bassett Jones's contributions to the Transactions of the American Illuminating Engineering Society. He shows how some of them were met in the Band Box Theatre (New York) by special lighting devices. With the high candlepower gas-filled lamps now available one would expect masses of small glow lamps to become obsolete, while "flood-lighting" units will no doubt often replace the arc, the manipulation of which calls for some care. A special point emphasised by Mr. Bassett Jones was the careful design and standardisation of lighting appliances, with a view to simplicity and robustness—qualities of considerable importance to companies going on tour.

---

* May, 1911.

Finally, I concur in Mr. Archer's suggestion that there should be moderate lighting of the auditorium while the play is in progress. The illumination should admittedly be much less than that provided on the stage, but a general illumination of, say, one-tenth to one-fifth of a foot-candle would relieve the unnatural contrast of a darkened auditorium without destroying the effect of the stage. Ordinary scenes probably involve a general illumination of the order of at least 10 foot-candles. In night scenes, when the lighting is dim, the illumination in the auditorium should be diminished, the aim being to preserve a fairly constant ratio between the brightness of stage and auditorium. In the case of sunset and sunrise, the effect might be enhanced by a simultaneous increase in brightness, both on the stage and in the auditorium. Good diffusion and complete absence of exposed filaments in the auditorium are, of course, vital. It may be recalled that a weak illumination is now becoming general in the auditoriums of cinema halls, and theatres have not the difficulty that requires to be guarded against in this case, *i.e.*, the possibility that even a weak general illumination may impair the image on the screen. It is a question whether the sharp demarcation between stage and auditorium, emphasised by the lighting conditions, is desirable on æsthetic grounds. I believe that in the convention of the Japanese stage this demarcation is much less evident.

(*Added:*—Mr. GORDON CRAIG writes to us from Italy expressing his interest in Mr. Fagan's paper. He mentions that he is engaged in preparing a treatise on the art of stage lighting and would welcome information from any member of the Society conversant with the subject, especially as regards existing books, diagrams, etc., dealing with theatre lighting. We shall be glad to convey to Mr. Gordon Craig any further interesting information of this nature that members can send us.—ED.)

Mr. J. B. FAGAN, in reply, said he was much interested in the reference made to the lighting of theatres in early times by Mr. William Archer, who had special knowledge of this period. He (Mr. Fagan) did not intend to convey that there was no lighting at all in theatres prior to 1682, but there was very little available information on the nature of such lighting, and it must have been primitive. Mr. Morrison had also referred to this point. It seemed likely, however, that at the masques arranged at the houses of noblemen some form of special lighting would be provided.

Mr. Archer had referred to the possibility of unduly elaborate lighting distracting the attention of the audience. This matter, he thought, had been disposed of by other speakers. He agreed that if the lighting was well conceived it should not distract attention, but rather that its sub-conscious effect would enhance the value of the play.

In his paper he had remarked that Mr. Gordon Craig had vitalised the Art Theatre at Moscow. He might perhaps have said that he revolutionised it, to some extent, in connection with stage decoration. He agreed that it was often an advantage that the actor's face should not be too clearly seen. At times it produced a striking effect when the actor suddenly walked out of the shadow into the light.

As regards Mr. Digby's experience in visiting the theatres of Germany some time ago, he thought that if he had done so immediately before the war he would have seen lighting effects which were not usual in this country. He entirely concurred in Mr. Digby's remarks as to the prejudicial effect of calling in the lighting expert at the last minute. There should be co-operation, at as early a stage as possible, between everybody concerned in the production of a play.

He did not think that the use of a large number of small gas-filled lamps would be as good as a few high-power lamps unless the light was very well diffused; otherwise there would be certain differences in light-values and shadow effects which interfered with the attainment of perfect lighting. In general he thought that the idea of illuminating objects of a certain colour by light of a different colour would not be successful. In colour effects it was often desirable to mingle with general diffused light over the entire stage a certain amount of light of the same colour as the object illuminated. This at any rate corresponded with the effect seen in nature, when an artist was aware of a certain amount of colour-reflection from an object in the surrounding atmosphere.

WATER-POWER IN THE BRITISH EMPIRE.

A SECOND Report has been issued by the Water Power Committee of the Conjoint Board of Scientific Societies, in which further particulars are given of the immense potential resources in water-power within the British Empire. Investigations are proceeding in India and Ceylon; in Canada the advantages of hydro-electric generation are already fully appreciated, and in Australasia, especially Tasmania, it has been making rapid strides. Of special interest is the exploitation of water-power in British Guiana, where large deposits of bauxite have recently been discovered. In this Colony there are known to be vast reserves of water-power awaiting use, notably the fall in the Kaietur Gorge on the Potaro River, where there is a total drop of about 1,000 ft. There are also falls in British New Guinea, where large rivers carry tremendous quantities of water to the coast from the huge mountain systems.

One important matter emphasised in the report is the training in hydro-electric engineering necessary for such enterprises. In some cases development has already been retarded by the lack of qualified engineers, and it is desirable that proper courses should be arranged at some of the chief engineering schools and colleges in this country.

THE EXAMINATION OF METALS BY X-RAYS.

THE discussion on this subject at the joint meeting of the Röntgen and Faraday Societies on April 29th raised many interesting points. It was shown that prominent flaws and blow-holes in pieces of iron and steel can be detected with comparative ease, provided the depth of material is not too great (20—40 mm. according to type seems at present to be the limit). It would, however, add vastly to the practical utility of the process if larger masses, with a thickness of, say, 40 cms. could be studied. Another limitation to the method is the fact that it is necessary to use photography as satisfactory indications cannot yet be obtained with the fluorescent screen for this work. It appears that this is chiefly a matter of sensitiveness, though probably the definition with such screens is also not so good. (Possibly in some branches of work, for example in judging the density of different masses of steel, the use of the fluorescent screen might be brought more within the practical limits if recourse was had to an illumination photometer to measure the brightness.) Further progress seems to depend either on the attainment of greater sensitiveness or of sources of X-rays of much greater power than at present; but the results so far obtained in this new field seem quite promising.

THE LIGHTING OF A BOXING ARENA.

By An Engineering Correspondent.

In the artificial lighting for gymnasiums, tennis courts, etc., the elimination of glare from the sources is specially important, because of the fact that the eyes of competitors are frequently directed upwards. A boxing display is an interesting example. A boxer must watch his adversary very closely and a moment's inattention, or failure to perceive his opponent's movements, may lose him the contest.

Attention is drawn to this point by "Corinthian" in a recent issue of the *Daily Chronicle,* when describing the recent fight between Towneley and Curzon.

"One of Curzon's greatest handicaps," it is remarked, "was being forced to look up the whole of the time to his taller opponent and thus receive the full glare of the too brilliant lights which surround the ring. At times he must have felt like a man meeting the headlights of a motor-car in a country lane."

It is clearly not an easy matter to light a boxing ring in such a way as to meet the requirements both of the boxers and the spectators. In order that the latter may be able to follow the contest closely from a distance a high illumination is necessary. Also, as a clear view of the stage from all directions must be presented, not very much use can be made of reflected light from adjacent surfaces. It would seem helpful to equip the lights with reflectors and place them as high above the boxers as possible, but inclined at different angles so as to eliminate, so far as possible, troublesome shadows. It might also be useful to screen the direct rays of the filament by frosted glass or other diffusing surfaces underneath the lamp.

A possible method would be to instal an "artificial ceiling" well above the stage and illuminate this indirectly. The height, however, would have to be sufficient not to impede in any way the view of the spectators, and there is the objection that the face of an opponent might still become indistinguishable if seen silhouetted against the white illuminated background—a circumstance which in view of the relatively large size of the bright area might occur fairly frequently. On the other hand, it might be urged that the gaze would only rarely be directed at this high angle and that the more important objection of seeing bright sources at angles approaching the horizontal is removed: and also that the diffused nature of the lighting would probably be helpful in illuminating the figures of the boxers in all positions. Should there be unsatisfactory shadows arising from the overhead rays of light these might be corrected by the use of indirect footlights. The greater consumption of energy necessary to produce a high illumination by this method would presumably be a small item in comparison with the total expenditure in staging such a contest.

AN APPARATUS FOR RECORDING INTENSITY OF DAYLIGHT.

A short account is given in the *Electrical World* of an apparatus devised by Mr. F. A. Swan, of Boston, for measuring the intensity of daylight. The apparatus consists of two parts—a receiver and a recorder, the former being installed on the roof, the latter in a cabinet in the laboratory of the Boston Edison Co. The device operates on the principle of a Wheatstone bridge, being in balance when no light falls upon it, but producing a small current when the receiver is exposed to light. The ensuing galvanometer deflection is recorded and in this way a chart of daylight-intensity throughout any day can be mapped out. A marked difference is visible between the record on a fine day and a rainy one.

These records have been of practical use to the supply company. It not infrequently happens that a customer object to the charge for electricity during the winter, basing his objection on the smaller amount due for the corresponding month in the previous year. But if the company has on file records of the two months showing the percentage of dark and cloudy days in both cases, it is possible to show the customer that his increased consumption of electricity may be due to climatic conditions.

INDEX, May, 1919.

PAGE
Boxing Arena, The Lighting of a .. 134
Daylight, An Apparatus for Recording .. 134
Editorial. By L. GASTER .. 113

Illuminating Engineering Society—

(Founded in London, 1909)

Account of meeting on April 8th .. 117
New Members .. 117
"**The Art of Stage Lighting,**" By **J. B. Fagan** (of the Royal Court Theatre) .. 118
Discussion:—Mr. WILLIAM ARCHER—Mr. THOS. J. DIGBY—Mr. G. E. MORRISON—Mr. N. R. BOOTH—Mrs. K. SEARLE—Mr. N. McDERMOTT—Mr. J. W. T. WALSH—Mr. HOWGRAVE GRAHAM—Mr. W. G. RAFFÉ—Mr. LANE CRAWFORD—Mr. JOHN DARCH—Mr. L. GASTER—The President (Mr. A. P. TROTTER)—Mr. G. A. APPLEBEE—Mr. J. S. DOW—Mr. GORDON CRAIG—Mr. J. B. FAGAN (*in reply*) .. 124
Metals, Examination of, by X-rays .. 133
Mine Lighting and Safety .. 136
Personal Notes .. 136
Reviews of Books and Publications Received .. 135
Royal Sanitary Institute, Annual Congress .. 136
Street Accidents .. 136
Trade Notes .. 136
Water-power in the British Empire .. 133

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

The Principles underlying Radio Communication (*Radio Pamphlet No.* 40, *prepared by the Bureau of Standards under the direction of the Chief Signal Officer of the United States Army, issued December* 10*th*, 1918, *pp.* 355, *figs.* 268).

THIS book aims at giving a general survey of the principles of electro-magnetism and their application to radio communications. While written primarily for Army use it contains much matter of general interest. The early chapters deal with fundamental principles, the nature of batteries, conductance, resistance, impedence, etc. Following this we have chapters devoted to dynamo electric machinery, radio circuits, electro-magnetic waves, apparatus for transmission and reception, and vacuum tubes used in radi-communication; appendices contain suggestions for laboratory experiments and lists of units and symbols. The method of treatment is simple and practical, and the text is illustrated by many illustrations, some of which, however, seem rather rough as regards draughtsmanship, although they are adequate in conveying their meaning.

THE *General Electric Review* (U.S.A.) for March contains a series of articles discussing the domestic applications of electricity. An article by Mr. E. J. Edwards dealing with lighting is included. The article contains some sound general hints on the lighting of drawing-rooms, bedrooms, dining-rooms, etc., and there is a frontispiece showing a very elaborate method of lighting a dining-room by the control of upwards of 400 lamps distributed above a cased-glass ceiling. It is remarked that the pendant shaded "dome" light has been coming into use again recently, and illustrations are given showing how, by the use of specially-designed portable units, an effective general illumination can be obtained. One interesting case discussed is the lighting of a bathroom originally lighted mainly by an inclined bracket light placed to the right of the washing basin and pointing downwards. This gave rise to a glaring effect. By substituting a prismatic reflector and adjusting the unit so that it pointed upwards a great improvement was effected. As light-coloured walls and ceiling are habitually used in bathrooms, there seems much to be said for such simple indirect methods.

MINE LIGHTING AND SAFETY.

GIVING evidence before the Coal Commission on May 14th, Mr. Frank Shufflebotham, Medical Adviser to the Ministry of Munitions, strongly emphasised the importance of good lighting in mines.

A certain amount of responsibility, he said, devolved upon the coal owners for not having insisted upon something being done to improve lighting conditions, especially in view of the prevalence of miners' nystagmus. In order to diminish accidents there should be a periodical survey of the causes. Accidents in mines should be notified, in the same way that infectious diseases are recorded, at regular intervals and published not only in Government reports but in the local papers. Improved illumination in mines, he added, would have the effect of reducing the number of accidents. If the miners could see better there would be fewer fatalities and improvements in miners' lamps would be very beneficial.

STREET ACCIDENTS CAUSED BY VEHICLES.

THE returns of the total fatal and non-fatal accidents for the United Kingdom, just issued, show the following results:—

		Fatal.	Non-fatal.
1918	..	2,193	35,732
1917	..	2,404	43,116

There is thus again a reduction in the number of accidents during the past year. It is probable that the improvement in public lighting is a contributory cause, though the form in which the statistics are presented does not enable this effect to be traced. One other influential cause of the diminution has no doubt been the energetic campaign of the London "Safety First" Council. When it is observed that out of the total figures for the whole kingdom London is responsible for roughly one-third of the fatal accidents and nearly one-half of the "non-fatal," the importance of propaganda in the Metropolis is evident.

ROYAL SANITARY INSTITUTE.

30th Congress and Exhibition.

THE 30th Congress and Exhibition of the Royal Sanitary Institute will be held, by invitation of the City Council, in Newcastle-on-Tyne from July 28th to August 2nd, 1919. A series of conferences and papers on important subjects has been arranged, and we observe that a section on Industrial Hygiene is included. Visits will be arranged to interesting public works in the vicinity. Further particulars may be obtained from the Secretary, Mr. White Wallis, 90, Buckingham Palace Road, London, S.W.1.

PERSONAL.

Readers will have observed with pleasure the Knighthood conferred on Professor R. A. Gregory who, as Chairman of the Organising Committee, contributed so largely to the success of the British Scientific Products Exhibition, organised by the British Science Guild last year. The corresponding exhibition during the present year will open on July 3rd and we understand that the number and variety of exhibits will be much extended.

TRADE NOTES.

ELECTRIC LIGHTING COSTS.

A BOOKLET under the above title, issued by Messrs. Tyler and Freeman (London, W.C.2), shows, by a series of detailed examples, how the costs of installation have advanced since the outbreak of war. The examples quoted include large and small houses, churches, factories, etc., the general impression being that costs have advanced 2—2½ times during the period 1914—1919. It is stated that the cost of labour for wiring has risen about 100—120 per cent., but as the output has fallen, the actual figure is probably nearer 125—130 per cent. Certain materials have, however, risen much more than this, notably wood-casing (350—500 per cent.) and opal shades (700—800 per cent.).

ELECTRICITY · ACETYLENE

The
ILLUMINATING
ENGINEER

Edited by
LEON GASTER

OIL · GAS

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

The Gas-filled Lamp and its effect on Illuminating Engineering.

The discussion on the above subject, opened by Mr. F. W. Willcox at the last meeting of the Illuminating Engineering Society, was timely, in view of the fact that many installations will now be overhauled, and much work in connection with lighting, left in abeyance during the war, will now be undertaken. The gas-filled lamp was becoming familiar in this country before the war, but its possibilities had hardly yet been studied completely. During the war-period its use in many directions was unavoidably restricted. There has been, for example, little opportunity of applying it to street lighting, and its chief field of utility has probably been in factories and munitions works of various kinds.

With the coming of peace a much wider field for the lamp has been opened. It is very important, therefore, as Mr. Willcox pointed out, that the precautions necessary in order to get the best results from the gas-filled lamp should be generally understood. Among the characteristics of the lamp that have been chiefly emphasised is its higher efficiency. The advantage in this respect, especially in the larger lamps, is undoubted, but in passing we should like to congratulate Mr. Willcox on the use of the term "gas-filled" to describe this form of lamp, instead of the dubious phrase "half-watt" which has admittedly given rise to much misunderstanding.

But another characteristic of the lamp, its very high intrinsic brilliancy, is of equal importance. This makes it essential to equip the lamp with scientifically designed shades and reflectors and to keep the lights well out of the normal range of vision. Consequently we find, in some cases, a predisposition to the use of indirect and semi-indirect methods, while, when direct lighting is used, the tendency is towards the provision of general illumination from a relatively small number of high candlepower lamps placed at a high level above the working plane. This "overhead" system of lighting will, we believe, continue to be widely adopted for many classes of work, notably for industrial lighting, and generally speaking in cases where it is desirable to produce a uniform illumination in all parts of a room. The method has the advantage of leaving the room clear, so that one can see from end to end, and it greatly mitigates the danger of glare. The question whether a few large candlepower units, or a greater number of lamps of smaller intensity should be used, requires careful consideration. Mr. Willcox was inclined to recommend the use of a few relatively high candlepower lamps (300—500 watt), on the ground that better and more efficient lamps are then obtainable, and that maintenance is simplified. But the drawback that the failure of one lamp may put a considerable area of the room in darkness must also be borne in mind.

In any case we would like to emphasise the point that such installations require special design, and that good results cannot be secured by merely substituting gas-filled lamps in existing fittings designed for ordinary tungsten lamps. The spacing conditions must be carefully planned to secure even illumination, and the fact that the distribution of light from most gas-filled lamps is quite different from that of a straight filament vacuum lamp in itself calls for specially designed reflectors. A further objection to the practice of installing gas-filled lamps in glassware or reflectors not intended for them is the unsightly effect due to the difference in the shape and overall dimensions of the lamp. To see a long-necked gas-filled lamp projecting from a shallow reflector, with the filament fully exposed to view and the light-distribution scarcely affected by the presence of the reflector is at once an indication of unsatisfactory lighting conditions. Used in this way the inherent advantages of the gas-filled lamp are lost. We may add that the same difficulty is sometimes experienced even when it is necessary to interchange gas-filled lamps of the same consumption and voltage. It is most desirable, therefore, that lamps of a given type should have bulbs of the same size and shape and that standard positions for the filament with respect to the bulb should be adopted. No doubt this matter will receive careful attention from lamp manufacturers.

To sum up, therefore, it must be recognised that the gas-filled lamp is a new thing, which requires new methods adapted to it. Properly used we believe it has a hopeful future in many fields of lighting, notably in streets, factories, on railways, etc., and in other cases where high candlepower units are desirable. It cannot be denied, however, that during the war there have been various factors which have limited its applications. Among these may be mentioned the high cost of lamps and difficulty in obtaining them, and the uncertain life met with in some batches. Unless a reasonably uniform life can be counted upon, the consumer loses the advantages that higher efficiency confers. An important point in this connection is the manufacture of the bulb and other parts of the lamp from the correct quality of glass. The use of unsuitable glass for such parts or imperfections in their assembly are largely responsible for premature failing of gas-filled lamps, and we hope that in the future glass manufacturers in this country will overcome these difficulties. We mention these as difficulties which have been encountered during the war, which are doubtless transitory. Everyone recognises the very difficult circumstances under which manufacturers have had to work. We trust, however, that they will now be removed, and if this is done the prospects of the gas-filled lamp in illuminating engineering appear hopeful.

Illuminations in Celebration of Peace.

Illuminations are to play an important part in the official period of rejoicing following the conclusion of peace, and already preparations are in evidence in London. The usual instinct towards brilliancy on such occasions will doubtless be accentuated on this occasion by the sombre conditions that have prevailed in the streets of London by night during the greater part of the war. Most of the attempts seem likely to be on familiar lines. In the present circumstances it is difficult to organise any very novel and striking light-effects, such as call for special design and appliances. The period of preparation is too short, and there are notoriously still considerable restrictions on limitations as regards both labour and supplies. We may therefore expect to see re-erected many devices which have already done duty on festive occasions before the war.

Nevertheless, while preparations may thus be largely of a "makeshift" order, we should like to urge the desirability of complying so far as possible with sound lighting principles. It is true that the mere use of light is associated with rejoicing, but it is obvious that the mere exhibition of a lighted lamp does not convey much. Far more can be done by the illumination of emblems, mottoes, etc., by concealed lamps, and in the crowded state of the streets it is certainly desirable to avoid the exhibition of very powerful lamps or flashing signs at a low level, which are liable to dazzle the eyes of drivers and pedestrians and prove dangerous to traffic. This point was emphasised at a recent meeting of the Street Lighting Committee of the London "Safety First" Council, and is one that those responsible for organising lighting displays might bear in mind. Private consumers cannot, in the present circumstances, do much in the way of spectacular lighting. But it may be suggested that if the existing lights in offices, etc., fronting on main streets are kept lighted, and the windows were covered with light-tinted material carrying appropriate designs, this form of diffused lighting effect would fulfil the purpose of the celebrations as well as assisting the illumination of the street. The effect would be enhanced if a uniform design could be employed throughout the street, thus forming a background of mild luminosity on which special luminous devices of greater brightness could be superimposed.

Realising as we do the need for economy, which is being strongly emphasised by the Victory Loan Campaign, we are reluctant to recommend the expenditure of large sums of money on lighting effects by municipalities and others. But we think that on this momentous occasion some effort in this direction might be made and we should prefer that this also should take the form of illuminating objects, rather than the assembly of masses of lamps. The best effect would be obtained by specialising on the illumination of certain centres, such as Trafalgar Square, the neighbourhood of Buckingham Palace, and the Mansion House. We understand that searchlights, which carried to many the ominous message of the arrival of hostile aircraft during the war, will be largely utilised Their use to illuminate, say, Nelson's column, preferably cleaned for the occasion, might well be considered. We should also like to see carried into effect the concealed lighting of the Victoria Memorial, whose white surface has long suggested it as a suitable subject for such treatment. There are also great possibilities in the use of aircraft and airships as an element in spectacular lighting, and an airship, flying at a low level and illuminated in the beam of a searchlight, could be most effectively used in this way.

The Victory Loan.

In connection with the Victory Loan Campaign, Sir Robert Kindersley, Chairman of the National War Savings Committee, entertained a representative gathering of the trade and technical press to a dinner at the Savoy Hotel, on June 17th. There were also present Sir Theodore Chambers, Mr. Sydney Walton (Publicity Director of the Victory Loan Campaign) and Mr. Hartland Swann.

Sir Robert Kindersley, after expressing his pleasure in meeting the members of the trade and technical press, remarked that the vast proportion of the population did not fully appreciate the difficulties with which the country was faced as a result of the war. The methods of finance adopted by this country and others were inevitable during the war. But now the time had come to return to a sound and solid financial system and to remove the mass of floating debt (really fictitious credit created by the banks) substituting a long-dated security in the hands of the investor, and thus freeing the resources of the banks for their proper use as a support of industry and commerce. This was the first step to be taken, before we could deal with such problems as the rise of prices and the cost of living. Sir Robert concluded by remarking that in spite of all the publicity that had been given to the matter there were still hundreds of thousands of people who were even unaware of the existence of war-savings certificates.

This point was also emphasised by Sir Theodore Chambers, who pointed out that while no immediate expectation of a marked fall in the prices of commodities could be expected, the movement in this direction would be assisted by the removal of the incubus of short-dated loans. He mentioned that there were over twenty million of people holding Government Stock, a fact which should prove a great safeguard to the future credit of the country.

Mr. Sydney Walton also appealed for the assistance of the trade and technical press in making the Loan a success, and thus paving the way for the rebuilding of industry and commerce.

We gladly take this opportunity of giving publicity to the Victory Loan Campaign, and we feel sure that the trade and technical press, which circulates widely amongst the manufacturers and employers of the country, will give its help in this matter, as it has done in connection with other objects of national importance during the war. What it is essential for everyone to realise is that only by his or her personal effort can this solid financial condition be restored ; it is not the support of the banks, which have other financial duties, but of the private investor that counts. This matter is of personal moment to each of these investors, for unless the objects of the Victory Loan Campaign are secured he will suffer personally. It is impossible to dissociate the financial credit of the State from that of the individual. Anything approaching a national financial collapse would cause widespread hardship and suffering, and must at all costs be avoided.

Finally we should like to express our appreciation of Sir Robert Kindersley's action in thus seeking the co-operation of the trade and technical press, and likewise of the enterprise of Mr. Sydney Walton, who is associated with him in this work, and to whose services Sir Robert paid a well-deserved tribute. In cases such as this, where the national credit is at stake, the trade and technical press is proud to be of assistance, and only desires that their co-operation should be sought on the same footing as the daily press in matters where both can be of service.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE GAS-FILLED LAMP AND ITS EFFECT ON ILLUMINATING ENGINEERING.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m. on Friday, May 30th, 1919.)

A meeting of the Society took place at the House of the Royal Society of Arts (18, John Street, Adelphi, London W.C.) on Friday, May 30th, the Chair being taken by Mr. W. R. Rawlings. General invitations to be present at the discussion had been sent to the Electrical Contractors' Association, the Association of Supervising Electricians, and the Association of Engineers in Charge, and a number of members of these bodies attended.

The Minutes of the last meeting having been taken as read the Hon. Secretary read out the names of the following applicants for membership :—

Best, William	Manufacturer of Miners' Lamps, Providence House, New Park Street, Morley, Yorks.
Douglas, H. H.	Electrical Engineer, 31, Chelsham Road, Clapham, London, S.W.
Houghton, Capt. G. A.	Electrical Engineer, Sandyknowe, Compton, Surrey.
MacDermott, N.	Everyman Theatre, Great Russell Street, London, W.C.
Stephens, J. N.	Electrical Engineer, The British Thomson-Houston Co., Ltd., 77, Upper Thames Street, London, E.C.

The Hon. Secretary also read out the names of applicants announced at the last meeting on April 8th, who were formally declared members.*

The Chairman then called upon Mr. F. W. Willcox to open the discussion on "**The Gas-filled Lamp and its effect on Illuminating Engineering.**" The following also joined in the discussion: Mr. Haydn T. Harrison, Mr. A. Blok, Mr. Chas. A. Baker, Mr. S. B. Langlands, Mr. H. J. Cash (President of the Electrical Contractors' Association), Mr. A. Cunnington, Mr. A. C. Cramb, Mr. H. W. Cole, Mr. E. W. Lancaster, Mr. C. E. Webb, Mr. L. Gaster, Mr. N. Arundel, and Mr. J. S. Dow.

A cordial vote of thanks having been passed to Mr. Willcox for opening the discussion, the Chairman announced that the **Annual Meeting** would take place on Tuesday, June 24th, when a discussion on "**Some Problems in Street Lighting**" would be opened by Mr. L. Gaster.

---

* Illum. Eng., May, 1919, p. 117.

THE GAS-FILLED LAMP AND ITS EFFECT ON ILLUMINATING ENGINEERING.

By Francis W. Willcox.

(Paper presented at the meeting held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Friday, May 30th, 1919.)

The radical revolution caused by the gas-filled lamp is summarised in the general statement that practically all electric lighting installations not re-equipped since pre-war days are more or less obsolete. The gas-filled lamp has profoundly affected the whole range of electric lighting practice. It adds superior light-efficiency to the simple characteristics and universal adaptability of the electric incandescent lamp, and in fact provides one universal type of lighting unit. The range of sizes available is shown in Fig. 1. Table A gives the detailed values for both gas-filled and vacuum type lamps, and illustrates the substantial increase in efficiency (lumens per watt) brought about by the gas-filled lamps. The indications clearly point to the practically universal adoption of the gas-filled lamp for all classes of electric lighting service. The replacement of other lamps has already reached considerable proportions, and would have been far more widespread but for certain restricting conditions incidental to the war.

In the face of this radical change electrical contractors and illuminating

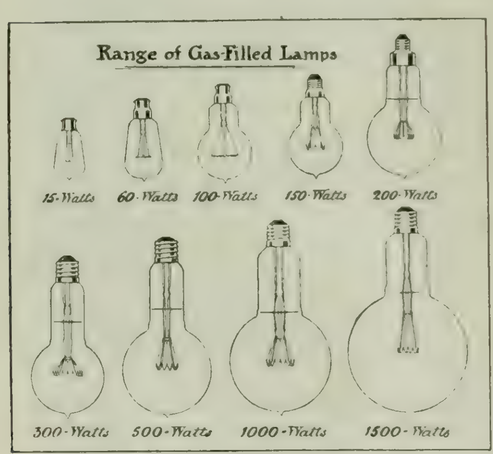


Fig. 1.—Range of British-made gas-filled lamps. Scale: 1 to 12½.

Table of Detailed Values of Standard Metal Filament Lamps.
(Great Britain.)

Volts.	Total Watts.	Total Lumens.	Lumens per Watt.	Spherical Reduction Factor (per cent.)
Vacuum Type.				
100 to 130	10	75	7·50	78
	20	163	8·15	
	30	255	8·50	
	40	341	8·50	
	60	535	8·90	
	100	930	9·30	
200 to 260	20	147	7·35	79
	30	229	7·63	
	40	330	8·25	
	60	515	8·60	
	100	905	9·05	
Gas-Filled Type.				
100 to 125	60	750	12·50	110
	100	1,300	13·0	
	150	2,100	14·0	
	200	2,800	14·0	80 to 90
	300	4,600	15·33	
	500	8,500	17·00	
	1,000	18,000	18·0	
	1,500	28,000	18·66	
200 to 250	100	1,200	12·0	110
	150	1,800	12·0	
	200	2,500	12·5	80 to 90
	300	4,200	14·0	
	500	7,300	14·6	
	1,000	16,500	16·5	
	1,500	26,000	17·33	

Table A.

engineers should consider the special characteristics of the new lamp, their effect on and relation to lighting service, so as to determine the lines of proper use, and to give effect to the most desirable lighting practice.

A certain measure of responsibility is involved in the installation of such brilliant and powerful sources of light. It is our first duty to safeguard the light user, the worker in factories and shops, and the public generally against the dangers of improper use of gas-filled lamps. A code of requirements to insure satisfactory diffusion of the light and elimination of glare is needed in order to restrict the bad practice of using bare lamps in the direct line of vision, in shops, shop windows and offices.

The introduction of the gas-filled lamp has emphasised the need for good lighting and has greatly promoted the evolution and application of good lighting methods. Hitherto, little attention has been paid, as regards the lamp, to the design of the fitting, beyond making the fitting generally suitable. The gas-filled lamps, especially in their big units, emit large amounts of heat and light, and light of an intense brilliancy. Such conditions require, not only that a fitting be used in every case, but also definite provisions in the design to insure the proper performance of the lamp and satisfactory service. The effect of the new requirements is to render the majority of existing lighting fittings obsolete. The new lamps should not be used in old fittings, except where such fittings can be made to conform to the new requirements. This will mean the discarding of the large majority of arm fittings, of the direct lighting type, including drop-lights with conic opal shades and cluster fittings, which are entirely unsuited for use with the new lamps. (See Fig. 32.)

We have thus reached a period of great opportunity in electric lighting, where a large proportion of unsubstantial, unattractive and encumbering drop-cord fittings, dangling lamps at the level of one's eyes, and other crude, unscientific, and wasteful lighting methods and appliances can be displaced.

FEATURES OF THE GAS-FILLED LAMPS THAT HAVE MODIFIED LIGHTING PRACTICE.

Modifications of previous lighting practice, lamp fittings and equipment, are occasioned mainly by the following features of the gas-filled lamp :—

(1) The very high intrinsic brilliancy of the filament, due to its high temperature and concentrated (spiralised) form.

(2) The provision of large lamp units of high candlepowers with increased efficiency in each larger size.

(3) The alteration of the lamp filament in form and vertical length of mount. The filament as mounted in the gas-filled lamp is concentrated into a circular space of very small dimensions compared to the space occupied by the filament as mounted in the vacuum type lamp. (See Fig. 2) and the height of the filament for the gas-filled lamp is also relatively small. This is the case for all the larger sizes of lamps. In the smaller sizes the gas-filled lamp filament takes the form of a simple flat ring of spiralised wire.

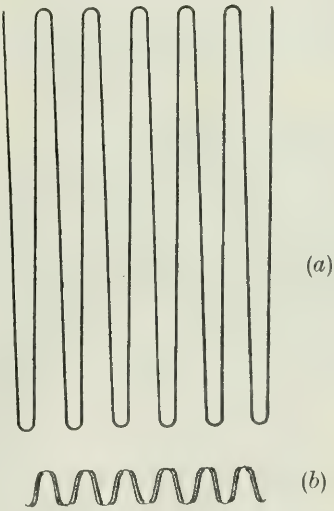


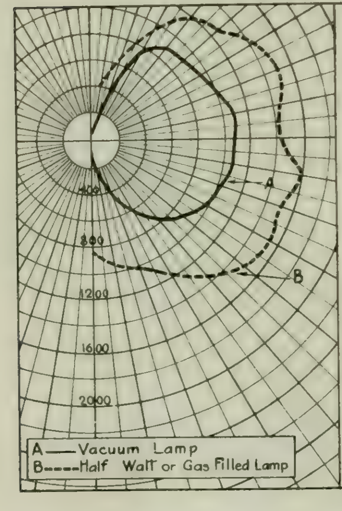
FIG. 2.—Relative sizes of shaped filaments as used in vacuum type (a) and gas-filled type lamps (b) to produce similar candle-powers at normal efficiencies.

This change in the filament causes material differences in the light distribution from gas-filled as compared to vacuum type lamps. The diagrams

(Figs. 3, 4, and 5) show various forms of filaments and corresponding polar curves. The variation is most extreme in the case of the flat ring type of filament which gives its maximum candlepower vertically (through the tip of lamp) while the ordinary vacuum lamp gives its maximum candlepower horizontally. (See Fig. 3.) The difference in candlepower and distribution between the vacuum lamp and the new lamp is also shown in the last column of Table A (p. 142) which gives the ratio (in per cent.) of the mean horizontal to the mean spherical candlepower.

EFFECT OF HIGH INTRINSIC BRILLIANCY OF THE FILAMENT.

The intrinsic brilliancy of gas-filled lamps, estimated at over 3,000 candlepower per square inch is three or four times that of the tungsten filament in the vacuum lamp, and the intrinsic brilliancy of the latter was in turn four times that of the old carbon filament.



ANGLE	C.P. A	C.P. B
0°	124	840
10°	207	940
20°	455	1000
30°	598	1200
40°	795	1350
50°	895	1490
60°	970	1550
70°	1020	1500
80°	1060	1610
90°	1070	1440
100°	1080	1450
110°	1020	1480
120°	980	1410
130°	920	1250
140°	870	1170
150°	650	900
160°	355	645
170°	148	390
180°	26	

FIG. 3.—Polar curves of light distribution showing candlepower values in vertical plane for bare metal filament lamps.

A .. 1,000 watt—250 volt-vacuum type.
B .. 1,000 watt—250 volt gas-filled type.

The intrinsic brilliancy of the gas-filled lamp is thus many times the limit to which the eye should be exposed. Such lamps, therefore, should not be used with the bare filament in the line of vision, as such misuse results in :—

(A) Glare and discomfort and consequent reduction of visual efficiency.

(B) Possible injury to the eye-sight.

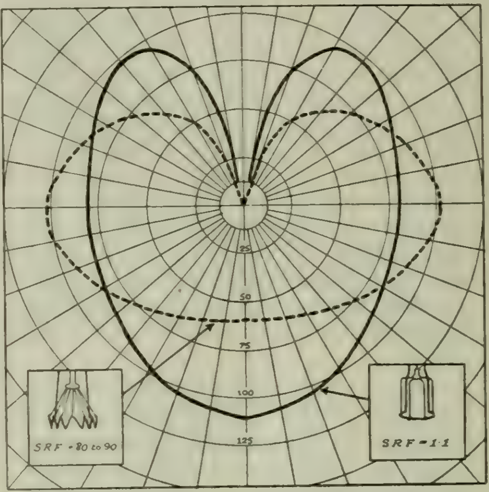


FIG. 4.—Polar curves of light distribution in Vertical Plane of gas-filled lamps (1).

Full line ..	Ring form of filament.
Dotted line ..	Zig-zag filament.

Frosting the lamp bulb is not sufficient to properly reduce the brilliancy of the filament, and special methods must be employed to properly diffuse the light and reduce the intrinsic brilliancy of the impression received by the eye.

The effect of this condition has been to emphasise the use of semi-indirect and wholly indirect methods of lighting. Direct lighting methods with the lamp hung in open reflectors are generally unsuitable with the gas-filled lamp in office, shop and home lighting, as even with the lamps placed directly upon the ceiling, the heights of most rooms are such as to permit the brilliant direct rays from the lamp reaching the eye. The old arm fitting with hanging lamps in ordinary reflectors, and the drop light with conic opal shade should, therefore, give way to some form of bowl fitting in which the light of the lamp is properly diffused by the glass bowl or dish, or with indirect lighting diffused by reflection from the large surface of the ceiling.

In industrial lighting, factories and mills, the height at which lamps can be hung is frequently great enough to permit the satisfactory use of direct lighting equipment, such as vitreous enamelled reflectors, but here also it is well to provide for better diffusion of the light by the use of what are termed "diffuser caps." These have the form of an opal cap or skirt hung beneath or around the lamp inside the reflector. (See Figs. 18 and 26.)

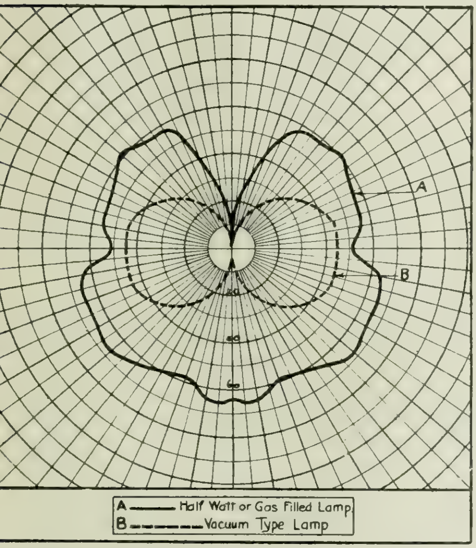


FIG. 5.—Polar curves of light distribution showing candlepower values in the vertical plane for bare metal filament lamps.

A .. 60 watt—110 volt vacuum type.
B .. 60 watt—110 volt gas-filled type.

The necessity for equipping and using the new lamps so as to safeguard light users against effects of glare and eye-sight troubles cannot be too strongly emphasised in view of the tendency on the part of many users to employ the new lamps in exposed positions by substituting them for previous lamps in existing drop-light fittings.

THE EFFECT OF LARGE UNITS OF CANDLE-POWER.

The first gas-filled lamps produced were of the larger sizes, 1,000 to 2,000 c.p. or more, and these sizes give the highest efficiencies. Smaller units were subsequently developed at some reduction in the efficiency given by the larger units. The availability of large units of light and the tendency towards the use of the larger sizes, due to the gain in efficiency, has the effect of—

(1) Reducing the number of lamps and points in interior lighting arrangement;

(2) Eliminating clusters of lamps and cluster fittings;

(3) Promoting the use of general overhead lighting and eliminating local lamps.

This in general tends to greater simplicity and is desirable from the illuminating engineering standpoint, as fittings can be more satisfactorily designed for the light distribution from single large lamps than for a cluster of lamps.

The promotion of general overhead lighting and the elimination of local lamps is an important result, as the many well-known advantages of general lighting, particularly for industrial establishments, will be given full effect and support. In brief, with the new large and highly efficient lamps, the illuminating engineer can locate his source of light from ten to fifteen feet up to 30 feet or more above the working plane. He is thus free to design and employ scientific lighting equipment which can efficiently deliver a uniform flood of light of any desired intensity over the working area of any interior.

Such a lighting system secures an economy in cost over old methods. It saves—

(A) On first or investment cost by reducing to a minimum the number of points required, and therefore the amount of wiring and number of lamps and fittings;

(B) On operating cost by giving increased efficiency of illumination and by reduced maintenance cost due to the smaller number of lamps and fittings.

The lighting of an interior will thus be made, like daylight, a general feature. Lighting service will be as separate from and independent of the workman and the work as is the roof and the protection it gives from rain and weather. The economies and advantages of employing the largest gas-filled lamps need to be emphasised, as some tendency exists to specify and use the smaller lamps—200 or 300 watt size, for example, where the 500 watt size could be better employed.

It is of special importance to employ these new large and powerful lamps with correct and scientific designs of fittings, of ample size and capacity, to have them properly installed at correct heights and spacing distances, to see that the lamps are properly focussed and to ensure that the system is kept clean and lamps periodically renewed. Modern lighting, employing such large units of lamps and fittings, is a new and interesting development, as the lighting engineer has never before had at his disposal for general lighting service such powerful equipment in simple form as that now available for the 1,000 watt and 1,500 watt gas-filled lamps. These introduce an element of great lighting power, coupled with an effective control of light distribution for all classes of lighting, comparable with that of the searchlight in its own field.

THE EFFECT OF ALTERATION IN SIZE AND SHAPE OF LAMP FILAMENT.

The material reduction in the size of the mounted lamp filament (see Fig. 6) considerably alters the problems of distributing the light from a reflecting surface. The long vertical section of the ordinary or vacuum lamp filament, giving the maximum candlepower in a horizontal direction, permitted the engineer considerable scope in manipulation of the light distribution. A greater variation of light distribution is possible than in the case of the gas-filled lamp filament of very short vertical length or the flat ring filament (see Fig. 7). In point of fact, it is found impossible to obtain wide angle or extensive light distribution (spacing ratio of 2 to 1) (see Fig. 20) in any type of simple over-reflector with the form of filament used in gas-filled lamps. As the polar curves show (Fig. 5) this filament gives a greater proportion of the light through the tip than the vacuum lamp does. Therefore to secure wide angle distribution it is necessary to put something beneath the lamp to deflect or refract the vertical component of light and thus increase the horizontal component.

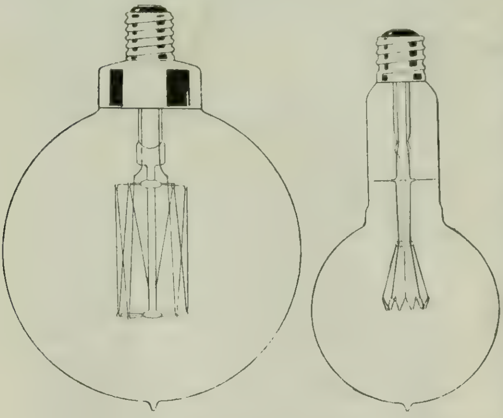


FIG. 6.—1,000 watt vacuum type lamp and 500 watt gas-filled lamp to same scale. Note relative size of filaments.

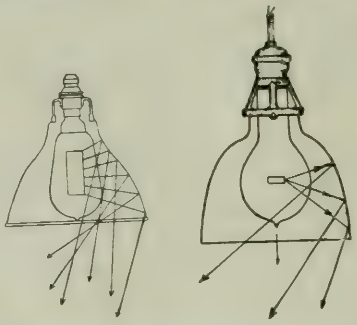


FIG. 7.—Light distribution from reflector. Effect of alteration of size of filament mount of vacuum type and gas-filled lamps.

Here we see a further reason for the use (already referred to under "Brilliancy effect") of some form of bowl fitting or the provision of opal diffusing caps or prismatic refractor bands around the bowl of lamp.

In illustration of this point, Fig. 8 shows a design of street lighting lantern employing a cone deflector beneath the lamp, thus securing the re-direction of the vertical light component to give the necessary wide angle street lighting distribution.

The compact form of filament also emphasises the need for more accurate focussing of the lamp in its reflector or other fitting. A slight variation in the position of the compact gas-filled lamp filament naturally causes a greater alteration of the light distribution than in the case of the longer vertical length of filament of the ordinary vacuum lamp. Some form of adjustment is therefore needed in order that the light-centre of filament can always be brought into the proper position. The importance of adjustable fittings is rendered especially necessary by the present variations in size of lamps from different makers; but even if all lamps were standardised to definite and uniform dimensions, as it is expected they will be in the near future, there would still remain the need for adjustment to permit proper focussing of the lamp filament, and secure the definite form of light distribution each fitting is designed to give. This is a most important feature, particularly when we are dealing with very large units of light.

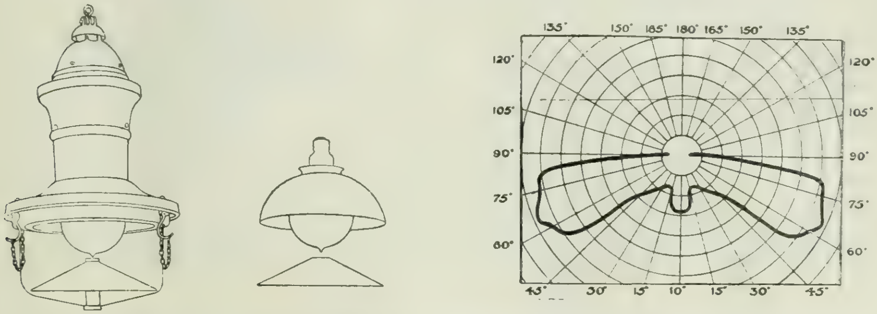


FIG. 8.—Type " I." Street lighting unit showing use of deflector and light distribution curve when equipped with a 500 watt gas-filled lamp.

The gas-filled lamp appears, therefore, to have altered lighting practice and design of equipment on the following important points :—

It encourages the use of semi-indirect or wholly indirect lighting equipment in preference to direct lighting.

It involves the elimination of clusters in favour of the single lamp units.

It favours the use of large single lamps in place of a number of equivalent small lamps.

It requires provision for preventing direct rays of the light from reaching the eye, *i.e.*, some means of diffusing the light and eliminating glare.

When these various facts are examined it will be seen that they are in the main most beneficial to the cause of good lighting and illuminating engineering.

In the first place, the gas-filled lamp provides, as already stated, a universal single type of electric lamp, and this makes for definiteness and simplicity of design in lighting equipment. The removal of glaring sources of light in the direct line of vision is one of the most important reforms that illuminating engineers have laboured for years to achieve. The more general employment of semi-indirect bowls, in attractive designs of glass or alabaster, introduces a note of charm and beauty into lighting seldom, if ever, before given with previous systems of direct lighting. The use of the indirect lighting system, dispensing as it can in many cases with any suspended fittings in a room, tends to promote a natural and unconscious condition of lighting akin to daylight. The adoption of a general overhead system of lighting with lamps located close up to the ceiling, or suspended at heights of 10 to 12 ft. or more above the working plane, obviates the disadvantages of local glaring lights surrounded by general darkness as commonly employed, and which condition oculists consider is prejudicial to eye-sight.

General lighting also conduces to cheerfulness, attractiveness, cleanliness and better working efficiency. Lighting equipment of inferior, inadequate and unattractive character has been all too generally employed. The gas-filled lamp happily assists the elimination of all such equipment, and furnishes not only the excuse but the necessity of selecting and providing a new line of fittings of a much higher standard of utility and beauty.

Therefore we have much to thank the gas-filled lamp for, in the material improvement it brings in promoting the use of lighting equipment of a much more effective and attractive character.

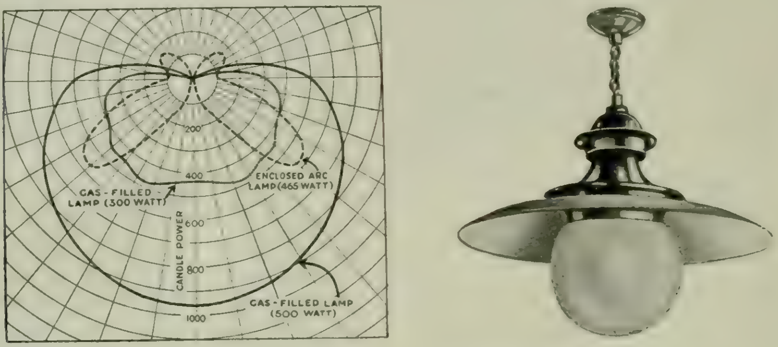


FIG. 9.—Enclosed arc *v.* gas-filled lamp.

Comparison of candlepower distribution curves from enclosed arc lamp taking 465 watts (clear outer and inner globes), and gas-filled lamps (taking 300 watts and 500 watts respectively) in fitting shown.

A GENERAL REVIEW OF THE EFFECTS OF THE GAS-FILLED LAMP IN VARIOUS FIELDS OF LIGHTING.

It will be helpful to an understanding of the changes the gas-filled type lamp has and will produce, to consider its effect in each field of lighting—in commercial lighting, industrial lighting, and street lighting.

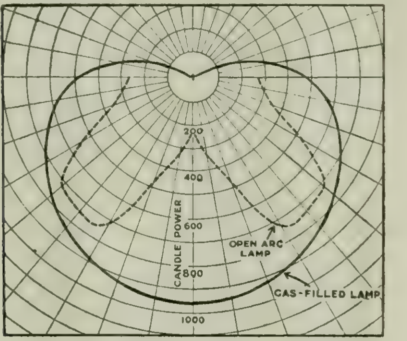


FIG. 10.—Open arc *v.* gas-filled lamp. Comparison of candlepower distribution curves of open arc lamp taking 500 watts, and gas-filled lamp taking 500 watts, equipped with fitting shown in Fig. 9.

Street Lighting.

The gas-filled lamp comes as a great boon to all municipalities and central station authorities in the provision of a simple, efficient type of lamp, free from mechanism and the need of adjustment or repair, and available in various sizes to suit all conditions from the most prominent city streets to residence streets and country roads.

The gas-filled lamp will have a wide vogue in street lighting work, where it has already had a widespread application. An interesting point of practice in the United States is the growing use of gas-filled lamps taking 20 amperes for street lighting. Such a lamp, with its heavy filament, gives the maximum of efficiency—20 lumens per watt (including loss in compensator) as compared to 16 lumens per watt for the 1,000 watt 200 volt. lamps. This is practicable where alternating current is available through the use of individual compensators at each lamp-post.

The problem in street lighting is that of distributing brightness, *i.e.*, of reducing contrast between light source and illuminated surfaces. The gas-filled lamp, when equipped with suitable appliances, can be made to satisfy the problem as well as, if not better than, other illuminants. The gas-filled lamp measures up well on the point of efficiency (see Figs. 9, 10 and 11) and maintenance cost, and scores heavily in the other considerations of

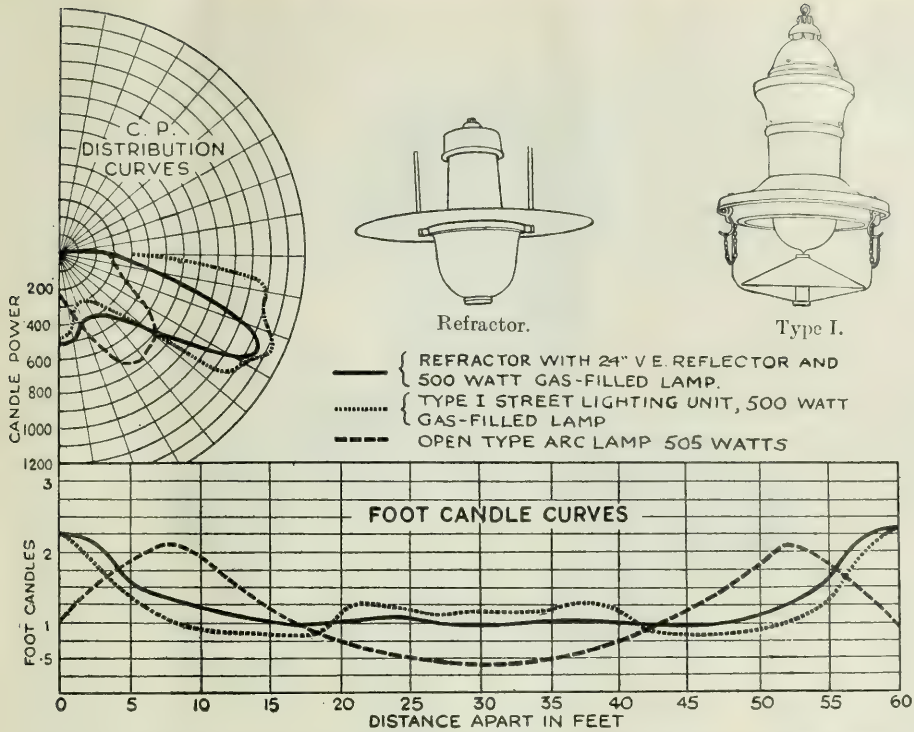


Fig. 11.—Relative illumination values for street lighting gas-filled lamps *v.* open arc lamps. Foot-candle curves of combined results given by two lamps placed 60 feet apart and 15 feet high in fittings as shown.

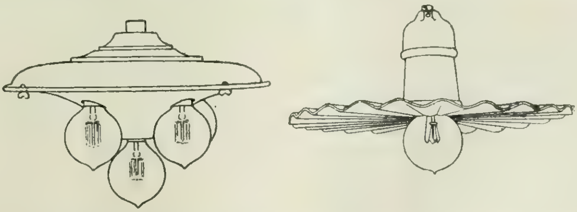


Fig. 12.—Street lighting equipment. Cluster fitting employed with vacuum type lamps. New single lamp fitting for gas-filled lamps.

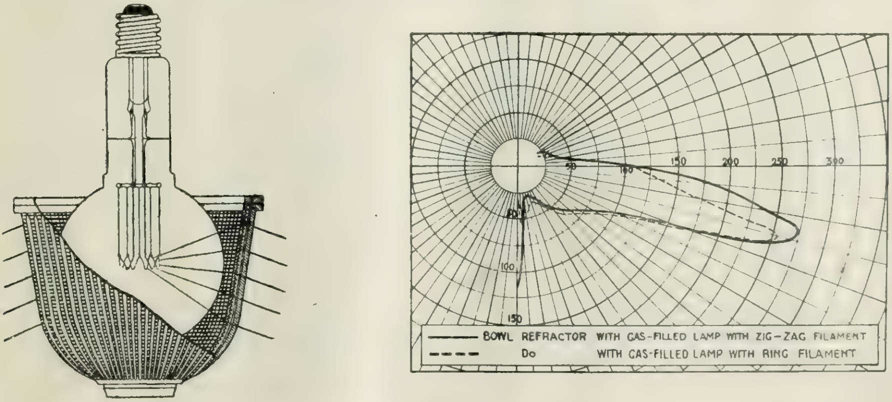


Fig. 13.—Holophane Bowl Refractor.
Polar curves showing light distribution from flat ring filament gas-filled lamp and zig-zag filament gas-filled lamp.

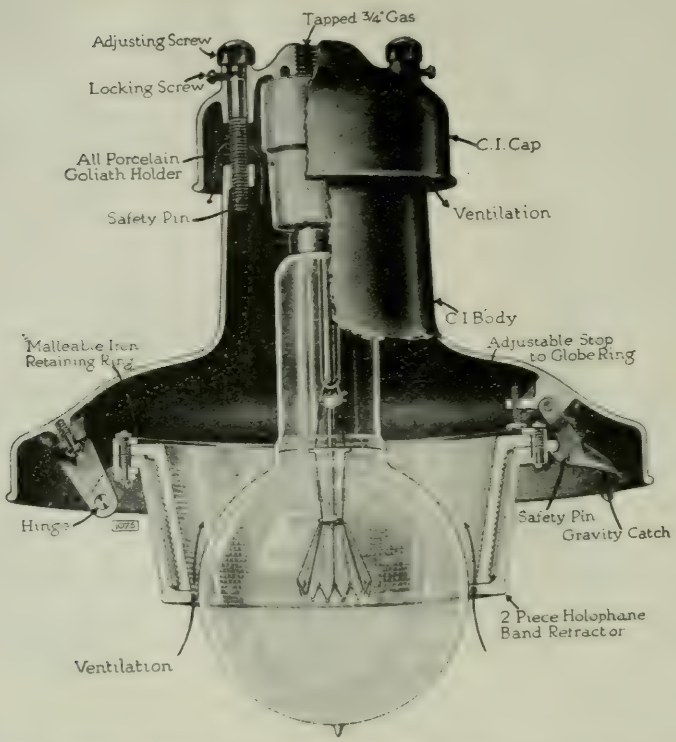
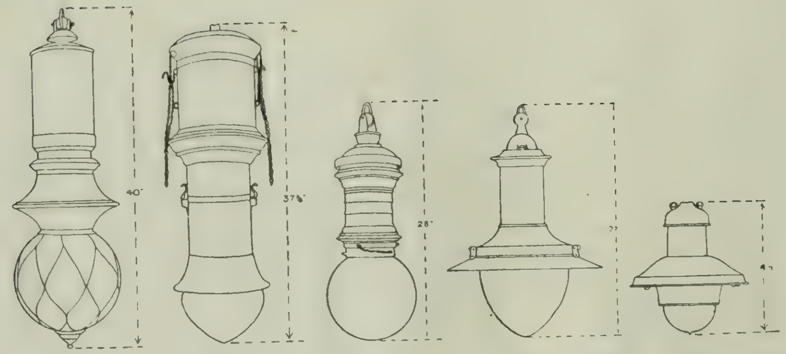


FIG. 14.—Section drawing of modern type street lantern for gas-filled lamps.



(A) (B) (C) (D) (E)

FIG. 15.—Size comparison in street lighting equipment.
Open arc (A), flame arc (B), and enclosed arc lamp (C), compared with two recent designs of lanterns for gas-filled lamps (D) and (E)—all to same scale.

adaptability, convenience, appearance, reliability and steadiness. A very marked advantage, as compared to arc lamps, is the reduced investment cost of the gas-filled lamp with its reflector or simple lantern.

The availability of various lamp sizes up to the largest (2,000 candlepower or more, see Fig. 1), with increase of efficiency as the size grows, will lead to the use of single units of lamps and the abandonment of clusters (see Fig. 12). The old incandescent lamp cluster-lantern will therefore pass, and the ornamental lamp-post bearing two or more lamps will give way to artistic and more economical single light posts.

The most important development for street lighting has been the prismatic glass refractor, either in band or bowl form, illustrated in Fig. 13. These refractors when employed with gas-filled lamps, give an excellent wide angle light distribution as required for street lighting (see Fig. 11). There is also now available for effective service with gas-filled lamps a variety of light density translucent glassware in pleasing forms—balls and vase-like globes—which glass gives good diffusion with high transmission (small absorption).

The elements of electric street lighting equipment, therefore, may be said to consist simply of the gas-filled lamp and a refractor or glass ball or globe supported by a simple housing containing lamp holder and wire connections. A type of lantern of this simple compact form is shown in Fig. 14 with the essential features marked. Street lanterns for gas-filled lamps required to be suitably ventilated, thoroughly weatherproof and stormproof, and made adjustable so as to permit ready and accurate focussing of the lamps. This latter point is essential where prismatic refractors are used.

Existing street lamp mountings have been designed in many cases for large, heavy-looking arc lamps, and this results in a tendency to require lanterns for gas-filled lamps to be made of the same long, heavy bulk—more than three-quarters of which is useless space. Fig. 15 illustrates the comparative sizes of arc lamps and lanterns for gas-filled lamps. One naturally questions whether it is desirable practice to slavishly follow the fashion of the arc lamp era, and after having built mountings to fit heavy arc lanterns, now to require that the lanterns be built to fit the heavy mountings. On this plan we will never be relieved from the heavy and ponderous obtrusiveness of much of our street lighting equipment. This is the time when advantage should be taken of the opportunity given by the introduction of the new gas-filled lamps to provide for new equipment of less obtrusive and more ornamental and attractive character.

This would appear an opportune time for the adoption of ornamental street lighting in Great Britain, in view of the success this form of lighting has had in the United States and Canada. This form of lighting with the smaller sizes of gas-filled lamps has a good field in suburban and residential streets.

The accompanying illustration (Fig. 16) shows some attractive types of street lighting equipment in use, and is interesting as showing the possibilities for improvement in appearance. As the illustrations show, it is easy to equip the lamp in these ornamental fittings with band refractor to insure the proper distribution of the light. It is surely time that street lighting equipment

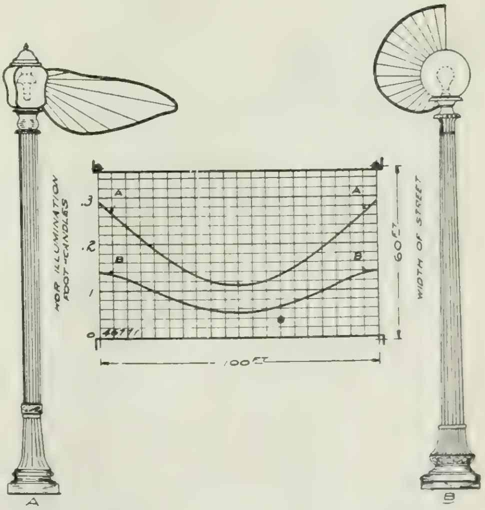


FIG. 16.- Ornamental types of modern street lighting units for gas-filled lamps (2).

A .. Refractor and globe.
B .. Diffusing ball.

should be made more ornamental and less obtrusive.

Industrial Lighting.

The war has given a great impetus to industrial lighting. It is in this field that the greatest progress has been made in illuminating engineering design and scientific lighting equipment. A series of various industrial lighting units for gas-filled lamps is shown in Figs. 17 and 18.

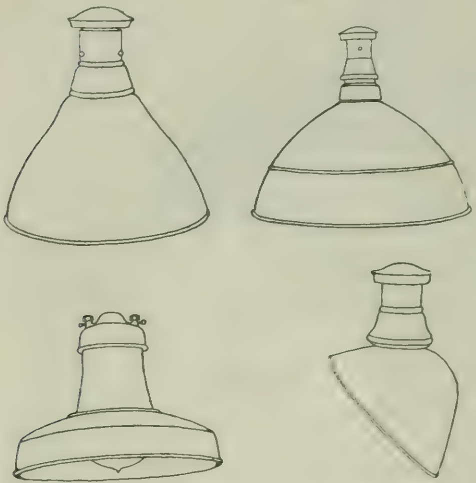


FIG. 17.—Types of industrial lighting units for gas-filled lamps. The fittings shown are of vitreous enamelled steel. (See Fig. 20 for polar curves.)

The requirements for industrial lighting in factories and mills are now provided for by legislative codes in various parts of the United States. Similar appropriate measures will, it is to be hoped, be taken in Great Britain in the near future. These lighting codes specify the minimum intensities of illumination required for various conditions and classes of work, and give general rules to be observed, two important examples of which may here be pertinently quoted:—

> " *Rule* 1.—*Shading of lamps.*
>
> " Lamps shall be suitably shaded to minimise glare.
>
> " NOTE.—Glare, either from lamps or from unduly bright surfaces, produces eye-strain and increases accident hazard.
>
> " *Rule* 2.—*Distribution of light on work.*
>
> " Lamps shall be so installed in regard to height, spacing, reflectors or other fittings and accessories, as to secure a good distribution of light on the work, avoiding objectionable shadows and sharp contrasts of intensity.
>
> " NOTE.—General illumination by properly arranged overhead lighting provides the best method of securing a good distribution of light on the work."

These rules constitute two fundamentals for lighting practice with gas-filled lamps.

It is an absolute essential that some form of reflector or fitting be used with gas-filled lamps in industrial lighting. It is also particularly important that correct and ample designs of reflectors and other lighting equipment be employed and a word of caution should here be given against the tendency to instal these new lamps in the same reflectors or fittings in which previous lamps are employed. This generally works out very badly, particularly in the case of previous shallow dome or conical enamelled iron reflectors. These expose the gas-filled lamp in the line of vision with the usual results of glare and loss of visual efficiency.

Freak designs (originated by works employees in many cases) are to be avoided. An example of such an improvised equipment (shown in Fig. 19) is productive of glare, forms an inefficient reflector, and is altogether unsuitable and bad practice. Many similar equipments are to be seen based on previous methods of attaching the reflector to the lampholder in total disregard of the long lamp

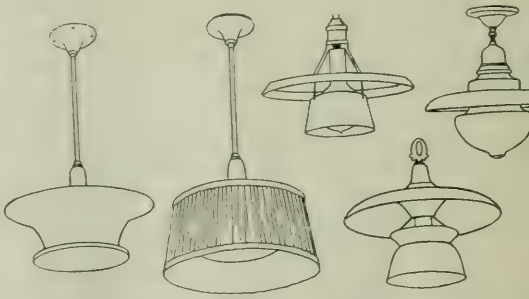


FIG. 18.—Types of lighting units for gas-filled lamps used in U.S.A.

neck, and the resultant glaring, protruded position of lamp. The importance of a suitable equipment, for shading, diffusing and properly distributing the light of the gas-filled lamp, cannot be over-emphasised.

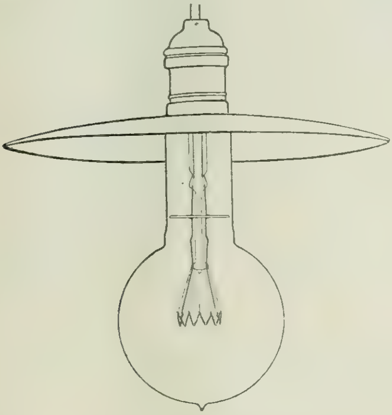


FIG. 19.—An example of bad practice in equipment of gas-filled lamps. Reflector not properly designed and in wrong position. Inefficient results and glaring light.

As already stated, general illumination with overhead lamps forms the best practice for industrial lighting with gas-filled lamps. This is provided for generally under three systems :—

(1) The direct lighting system which employs scientific designs of steel vitreous enamelled reflectors of various types. These are shown in Fig. 17 and with polar curves in Fig. 20.

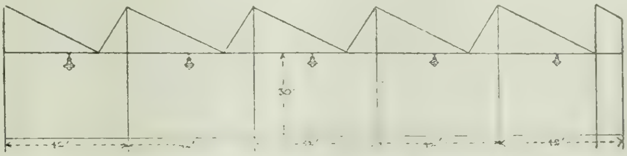


FIG. 24.—Cross section of works showing wide spacing possible with industrial fittings of semi-indirect (semi-enclosed) type equipped with large size of gas-filled lamps. Night view of interior lighted, shown in Fig. 26.

(2) Semi-indirect lighting. Under this system excellent results are given by a semi-enclosed unit of the type shown in Fig. 21. This type is specially suitable and effective in having a large over-reflector which makes the fitting independent of the ceiling, as ceilings are generally very unsuitable, if not entirely lacking in many works.

(3) The diffusing lighting system. This employs opal glass globes or other enclosure of diffusing glass supported by lanterns or galleries ; example given in Figs. 22 and 31.

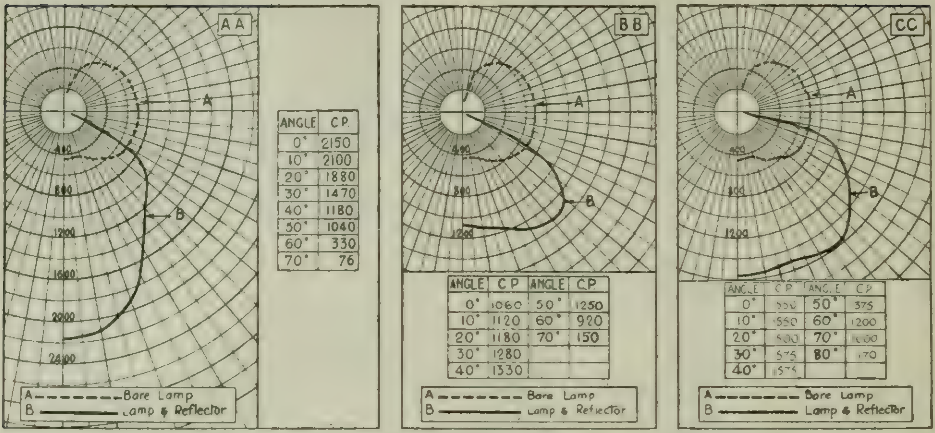
Of these three systems, the second or semi-direct system with semi-enclosed units (example of which is shown in Fig. 18), forms in general the most effective system for industrial lighting. For equal illumination of any given intensity, this system permits wider spacing of points than with the direct lighting types of vitreous enamelled reflectors. These semi-enclosed units, therefore, reduce to a minimum the number of points and the number of fittings and lamps required.

A good example of the use of semi-enclosed fittings is given in Figs. 23 and 24, which relate to an aeroplane factory near London, where 1,000 watt lamps are located on 42-foot centres 30 feet high.

The diffusing system has not the same possibilities for the scientific distribution of the light as with either the direct or the semi-indirect system.

In the case of both the direct and semi-indirect types of equipment, it is necessary to obtain efficient results, that the reflecting surfaces be sufficiently large to insure adequate reflection as well as satisfactory diffusion. This point is too often neglected and fittings made too small in an attempt to reduce the cost. There are many examples of over-rated fittings on the market—fittings, for example, rated for 500 watt lamps that are really not adequate in size for the 200 watt lamp. A comparison of results given by several types of semi-enclosed fittings is shown in Fig. 25 to illustrate the deficiencies of over-rated fittings as compared to one of adequate size.

Direct lighting is satisfactory for many cases of industrial interiors where the lamps can be suspended at considerable heights—18 to 20 feet or more.



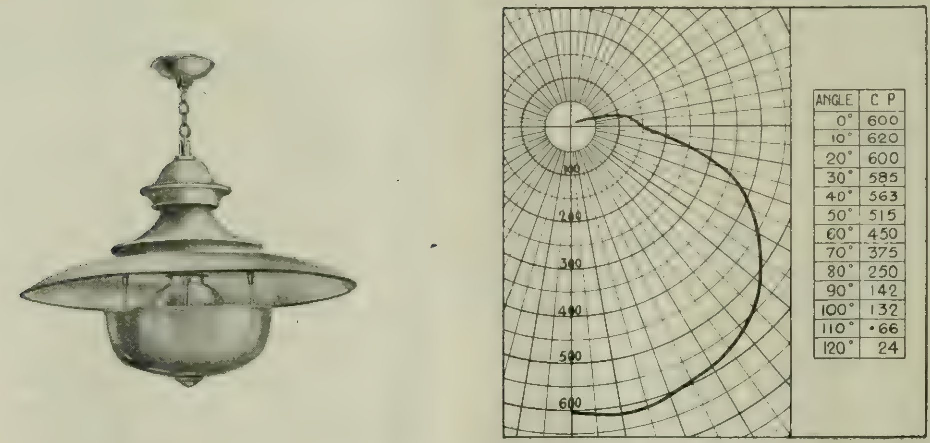
ANGLE	C.P.
0°	2150
10°	2100
20°	1880
30°	1470
40°	1180
50°	1040
60°	330
70°	76

ANGLE	C P	ANGLE	C.P.
0°	1060	50°	1250
10°	1120	60°	920
20°	1180	70°	150
30°	1280		
40°	1330		

ANGLE	C P	ANGLE	C P
0°	550	50°	375
10°	1550	60°	1200
20°	500	70°	600
30°	575	80°	170
40°	1575		

FIG. 20.—Polar curves of light distribution showing candlepower values in vertical plane given by a 500 watt-110 volt gas-filled lamp.

AA Focussing type vitreous enamel steel reflector		Illustrated
BB Intensive type ,, ,, ,,	}	in
CC Dispersive type ,, ,, ,,		Fig. 13.



ANGLE	C P
0°	600
10°	620
20°	600
30°	585
40°	563
50°	515
60°	450
70°	375
80°	250
90°	142
100°	132
110°	66
120°	24

FIG. 21.—Semi-indirect fitting, semi-enclosed industrial type, for gas-filled lamps with polar curve of candlepower values in vertical plane when equipped with a 300 watt-105 volt gas-filled lamp.

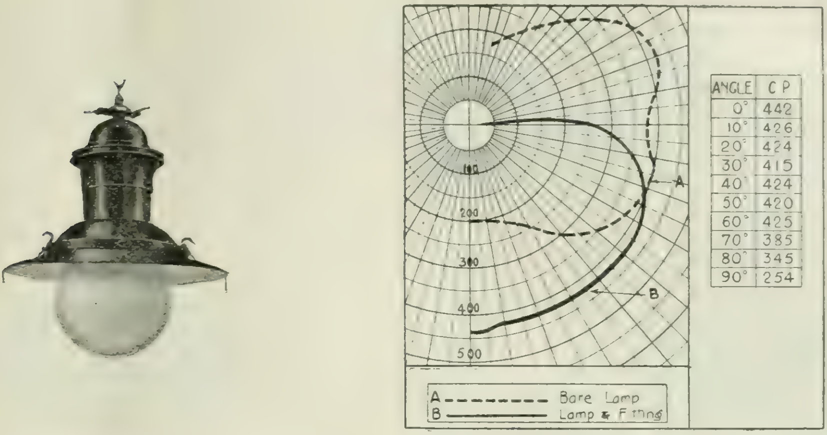


FIG. 22.—Weatherproof lantern for gas-filled lamps showing polar curve of candlepower values in vertical plane when equipped with a 300 watt-105 volt lamp.

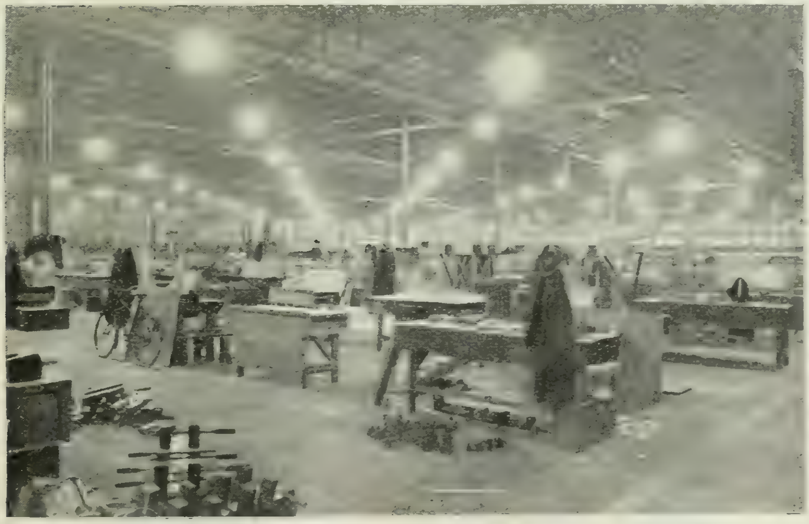
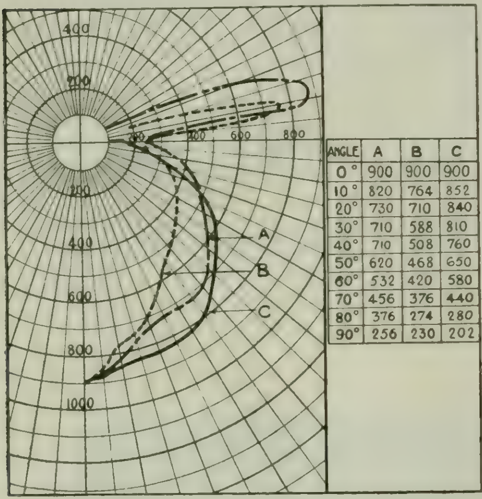


FIG. 23.—Night view of large aeroplane works equipped with 1,000 watt gas-filled lamps in semi-indirect industrial fitting shown in Fig. 21. Lamps spaced 42 feet apart and hung 30 feet above floor. Good example of employment of large units of light on wide spacings, thereby reducing the number of points and units to the minimum. Illumination, 3·5 foot-candles; specific consumption, 0·18 watts per sq. ft. Efficiency, 21 lumens per watt (*i.e.*, 21 foot-candles per watt per sq. ft.) Section of building shown in Fig. 24.

A special type of industrial equipment for gas-filled lamps, which gives excellent results, is shown in Fig. 27. This employs a lamp silvered on the bowl or tip end of the lamp to reflect the direct rays of light from lamp upward to the surface of the reflector. This is really an example of the indirect system of lighting, since no rays of light are transmitted directly but all are reflected.



ANGLE	A	B	C
0 °	900	900	900
10 °	820	764	852
20°	730	710	840
30°	710	588	810
40°	710	508	760
50°	620	468	650
60°	532	420	580
70°	456	376	440
80°	376	274	280
90°	256	230	202

FIG. 25.—Polar curves showing light distribution of three makes of industrial semi-indirect fittings for gas-filled lamps. Illustrates poor results in cases (A) and (B) of improper design and inadequate dimensioning of equipment. 500 watt-200 volt lamp in each fitting.

Commercial Lighting.

Commercial lighting includes the lighting of shops, offices and similar interiors. In this field of service, the gas-filled lamp leads to general overhead lighting by single, large lamps, under the following systems :—

(1) Semi-indirect lighting with simple opal glass hemispheres or ornamental forms of bowls of alabaster glass or real alabaster or marble.

Under this system are included the new types of semi-enclosed or wholly enclosed lighting units shown in Figs. 28 and 34.

There is a large field of application for such complete units, replacing arm fittings and lamp clusters. They are of value in providing lighting unit combinations that can safely be used to give the proper diffusion and distribution of light, and to prevent the glare and unsatisfactory results from attempting to use the new lamps in old fittings or reflectors and other unsuitable equipment.

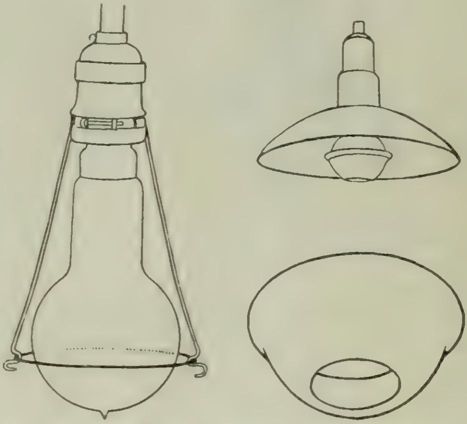


FIG. 26.—Type of modern industrial unit with diffusing cap for gas-filled lamp.

(2) *Indirect Lighting.* The light is reflected to the ceiling, from the large surface of which it is again reflected and diffused about the room, producing when properly done the most agreeable and effective of illumination results from gas-filled lamps. The equipment of mirror reflector and lamp is supported inside an upturned bowl which may be an opaque bowl or have luminous panels. (See Fig. 33.)

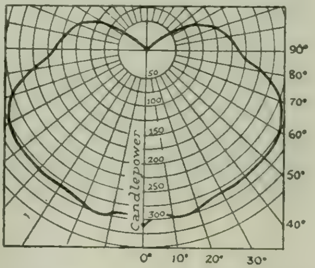
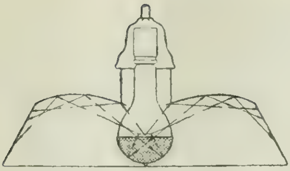
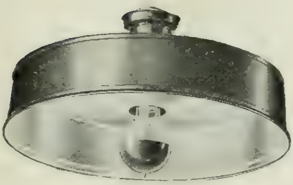


FIG. 29.—Polar curve of light distribution given by light units of type shown in Fig. 28.

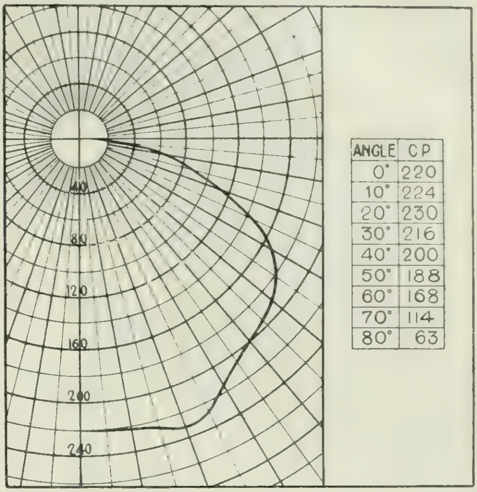
(3) Diffusing system employing a diffusing glass globe or ball around the lamp. (Fig. 31.)



Contour of Lamp Fitting.



General View.



ANGLE	CP
0°	220
10°	224
20°	230
30°	216
40°	200
50°	188
60°	168
70°	114
80°	63

FIG. 27.—Industrial fitting for gas-filled lamp, indirect type (employing lamp with bowl of bulb silvered) and polar curve showing light distribution in vertical plane as given by a 200 watt-100 volt gas-filled lamp.

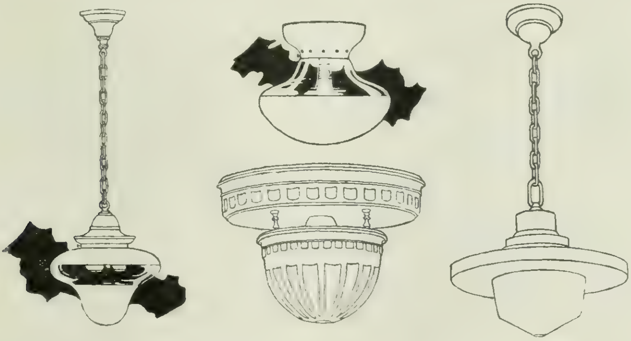


FIG. 28.—Types of modern enclosing light units for gas-filled lamps. Semi-indirect system.

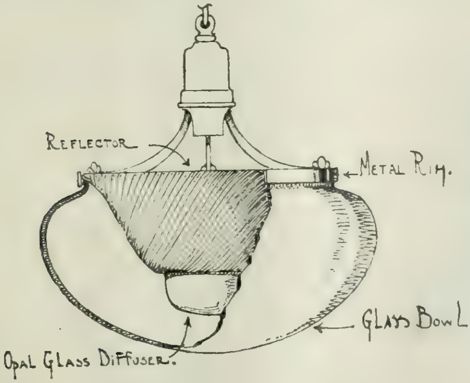


FIG. 30.—Sectional view of luminous bowl indirect fitting.

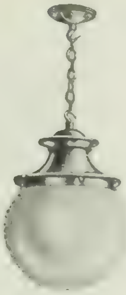


FIG. 31.—Commercial fitting for gas-filled lamps. Example of diffusing system with alabaster glass ball.

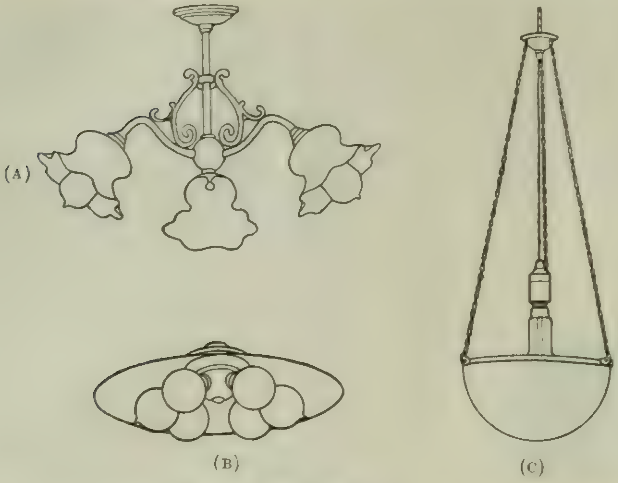


FIG. 32.—The old and the new.
Old arm fitting (A) and cluster fitting (B) for vacuum lamps. Type of semi-indirect unit (C) for gas-filled lamps.

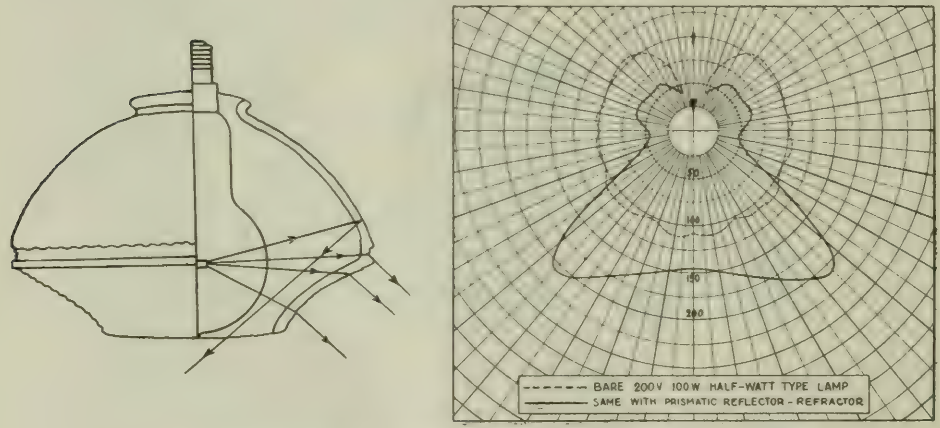


FIG. 35.—New holophane reflector-refractor for gas-filled lamps and polar curve.

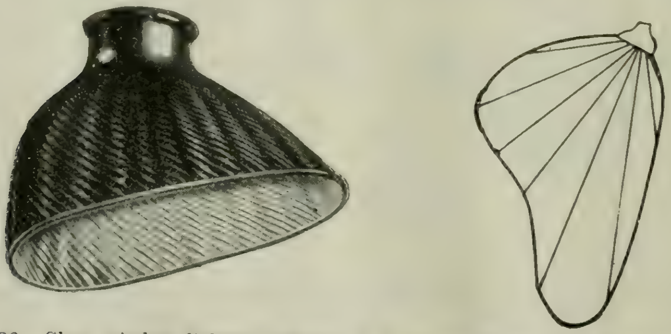


FIG. 36.—Shop window lighting reflector and characteristic light distribution.

The first and second systems are the ones most used as the diffusing system does not give the same opportunity for controlling the distribution of the light.

Some form of bowl fitting, therefore, is the predominant type replacing pendants, arm fittings, clusters and other direct lighting equipment. (See Fig. 32.)

The choice lies largely between the semi-indirect lighting and the indirect lighting system. The untutored user will, in general, express a preference for the semi-indirect system, because of the general tendency to select a fitting with the source of light visible. It is remarkable, however, how the opinion of users changes once they have had an opportunity of trying properly designed indirect lighting (see Fig. 33). Some notable examples can be given as showing how much more attractive and effective is the illumination from properly designed indirect lighting than from semi-indirect lighting. Extensive tests by Dr. Ferree in the United States have demonstrated that the eye suffers the minimum of fatigue under indirect lighting—less than with any other lighting system.

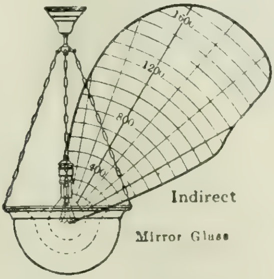


FIG. 33.—Indirect lighting fitting and polar curve—500 watt lamp (1).

A great variety of results are given by semi-indirect fittings, due to the difference in density of the glass employed and to inattention to the proper location of the lamp in the bowl (see Fig. 34).

It is of great importance that the glass bowls of semi-indirect fittings should be of sufficient density and give the greatest possible diffusion with a minimum of absorption. Where bowls of thin light glass are used the brilliancy of the light is apt to be almost as objectionable as direct lighting.

An interesting development in the prismatic glass reflector is the new Holophane Refractor-Reflector for gas-filled lamps shown in Fig. 35.

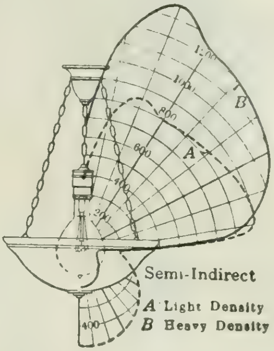


FIG. 34.—Semi-indirect lighting fitting and polar curve—500 watt lamp (1).

For show window lighting the new lamp requires deep reflectors completely hooding the lamp, and suspending the lamp in a vertical position (Fig. 36). This indicates an improvement on the usual trough reflectors (which require lamps to be burned horizontally), by the substitution of individual reflectors of special design, made in various types, to give the different forms of light distribution required for varying window heights and depths and height of window trim.

Lighting without Pendant Fittings.

In gas lighting, a chandelier or fitting hanging in the centre of the room was required to support the flame burners. Out of this practice grew the fashion

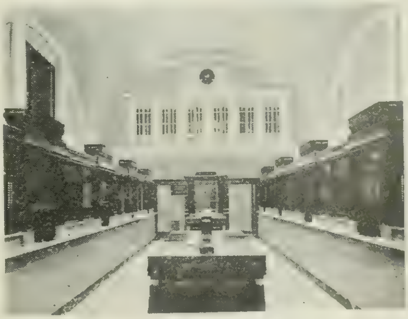


FIG. 37.—Indirect lighting of a bank. Lighting equipment located in the top of counter railings. Room free from any overhead or exposed fittings.

of the lighting fitting suspended from the ceiling. Electric lighting continued this fashion and the trail of the fitting is still over the lighting industry to-day. Now the gas-filled lamp in causing the obsolescence of direct lighting modifies the fitting into a bowl, and thus frees lighting from conventional equipment and methods. The indications are that this evolution will continue and will tend to eliminate the fitting as such, and clear the ceiling and interior of all exposed lighting equipment. Indirect lighting accomplishes this by:—

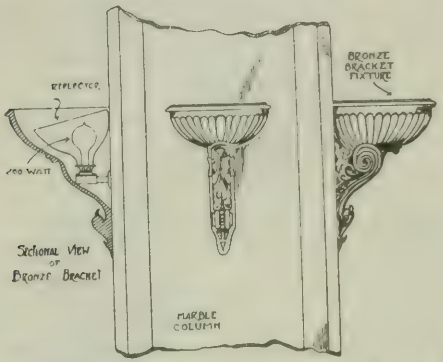


FIG. 38.—Elevation and sectional view of Bradict fittings for indirect lighting.

(A) The use of columns, pillars or other existing structures in the room—such as the tops of bookcases or bank railings or partitions to support lamps and reflectors. (See Figs. 37 and 38.)

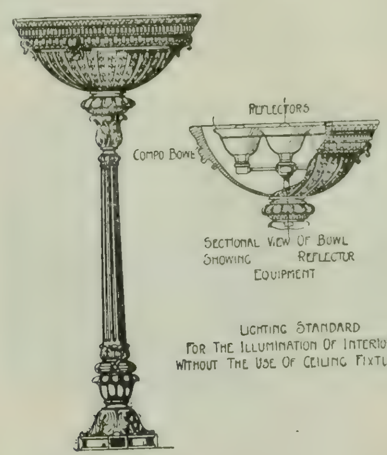

REFLECTORS
COMPO BOWL
SECTIONAL VIEW OF BOWL SHOWING REFLECTOR EQUIPMENT
LIGHTING STANDARD FOR THE ILLUMINATION OF INTERIORS WITHOUT THE USE OF CEILING FIXTURE

FIG. 39.—Floor pedestal standard for indirect lighting.

(B) The use of floor pedestals and table standards with equipment arranged to project the light upon the ceiling. (See Figs. 39 and 40.)

Lamps may be concealed in beautiful alabaster vases placed on mantels or table or pedestals to form attractive sources of light and agreeable lighting.

The use of artificial sky-lights and artificial windows and cornice lighting are other methods that dispense with any electroliers or exposed fittings, and have considerable possibilities with the high efficiency of the gas-filled lamp.

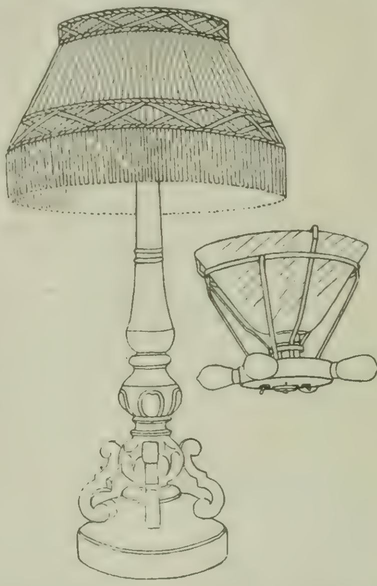


FIG. 40.—Table standard for indirect lighting, showing reflector equipment.

Projectors and Floodlighting.

In display lighting and lighting of exteriors, the gas-filled lamp has introduced what is known as flood lighting in place of the previous method of outline lighting of buildings and grounds with festoons or lines of lamps.

In this work the results have been accomplished by the wide use of projectors (Fig. 40) for which the new lamps are specially adapted. A most notable example of the beautiful and effective results possible with flood lighting of buildings was the Panama Exhibition at San Francisco, which was lighted throughout on this plan.

Flood lighting is very widely applied in various fields of exterior lighting for lighting of shipyards and docks, railway stations, goods yards, quarries; also for fire brigade, salvage and similar work, as well as patrol work. On the display side, it is usefully employed in the spectacular illumination of public buildings, monuments, fountains, hoardings, signs, as well as for outdoor festivities, winter sports, carnivals, theatricals, pageants, exhibitions, race tracks, etc. This subject is a very large one, however, and deserves an evening's discussion

Space does not permit more than a reference to the numerous other minor developments incident to the gas-filled lamp, among others the special application of this lamp to cinema projection work—on a new principle of "surface source" of light in place of a "point" source of light. Passing reference can also only be made to the use rendered possible by the high efficiency of the new lamp of special glass bulbs to give the quality of light required for (A) photographic work (photographic blue bulb), (B) or daylight quality of light for colour-matching (daylight bulbs); or (C) amber light and amber bulbs for producing soft-toned yellow light so agreeable and desirable in social conditions.

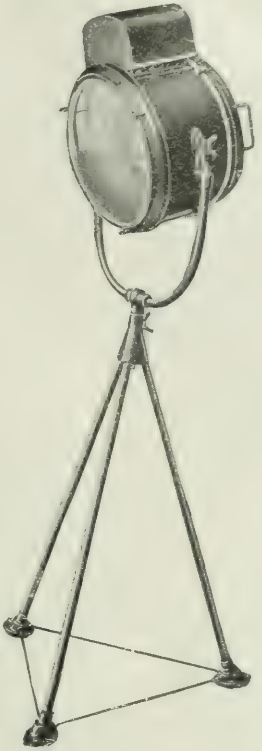


FIG. 41.—Floodlight projector for gas-filled lamp.

DISCUSSION.

Mr. HAYDN T. HARRISON congratulated the author on his paper, and also on using the term "Gas-filled" Lamps, because they were still often described as "half-watt," an expression which was apt to be misleading, especially as the actual watts per candle varied so greatly with the size of the lamp and the supply voltage. He (Mr. Harrison) wished that Mr. Willcox, when dealing with the variety of fittings illustrated, would state their efficiency in lumens, which was the unit Mr. Willcox had so often recommended for that purpose. The design of the globes, reflectors, etc., used with gas-filled lamps was of vital importance, in view of the fact that shading was essential owing to the high intrinsic brilliancy of the filament. If inefficient types of fittings were used, one might easily lose the advantages which the high efficiency of the lamp should confer.

A point on which he would like fuller information, therefore, was the actual luminous efficiency attainable with the various types of reflectors, etc. He noticed in Fig. 27 a 200-watt gas-filled lamp in a special reflector produced a maximum of 230 candlepower in its lower hemisphere and no light in its upper hemisphere, if the efficiency of such a unit had been computed on the lumen basis it would presumably have worked out at about 22 per cent. In such a case a consumer using a two candlepower per watt lamp lost all the advantage of the higher efficiency. He mentioned this point, not to depreciate in any way the advantages of the gas-filled lamp, which he believed had a great future in electric lighting, but in order to emphasise the importance of avoiding reflectors which apparently absorbed such a high percentage of light.

In connection with his work for the Navy he had tested a great number of concentrated filament lamps designed for projection purposes. Amongst these was one form of lamp made by the General Electric Co., of America, for flood-lighting work which had some interesting features. Instead of the filament being arranged round a circle of 1 in. diameter, it was arranged round a circle of ⅜ in. diameter and zig-zagged. Such a lamp would have valuable properties with prismatic distributing devices or focussing reflectors, as it would permit of a certain latitude in placing the lamp within the refractor. In other words, it would not be so vital to good distribution to get the filament in the exact theoretical position. He would much prefer this form of filament to those with a perfect corona type of large diameter, for the above reason. He wished to impress on manufacturers the desirability of utilising forms of filament which did not require very accurate focussing, or the provision of an inspection-aperture in the lighting fitting.

Mr. Willcox, in dealing with the effect of the gas-filled lamp on illuminating engineering, had naturally devoted most attention to its applications and accessories. There was general agreement that an increased illumination could be readily obtained with the gas-filled lamps, but there were other factors, such as cost, convenience of use and life which required consideration. He hoped that Mr. Willcox, out of his special experience, would be able to give them some information on these points. He was glad to find that some very successful results had been obtained with gas-filled lamps for street lighting and some trial installations for the purpose of investigating life had also been made. On the other hand, some very variable results in regard to life had been apparently obtained, a fact which was surprising to him because, in his experience in his work for the Navy, a very consistent good life had been found. He was inclined to think that, as regards the life of the lamp, much depended on the type of fitting. There was one type of fitting which he believed would be prejudicial, namely, that in which the lamp was entirely enclosed within a globe, having a small aperture at the base and a long ventilating duct above the lamp, in which case if cold air were sucked up through the aperture, so as to impinge upon the bottom of the lamp, only half an inch away from the hole, the ensuing difference in temperature at various parts of the bulb would not be favourable to long life. He calculated that in this case there must often be a difference in temperature of 100 degrees from the bottom of the lamp to half-way up.

Mr. ARTHUR BLOK also referred to the question of the life obtainable with gas-filled lamps. This, he said, was a matter on which somewhat conflicting experiences had been recorded, and he thought that reliable data would be welcome.

Mr. CHAS. A. BAKER (Electrical Engineer to the London County Council) remarked that one of the most important points brought out in the paper was the necessity for special design in the fittings used for gas-filled lamps. The problem of concentrated brilliancy had been met with many years ago in the arc lamp and had been practically solved by the use of opal glass globes or diffusers round the arc. He thought that modern high pressure gas lighting was a very good form of street illuminant, and it would be helpful if some sort of glass diffuser, the size of a tumbler, fitted inside or outside the gas-filled lamp, could be produced to yield a similar order of brilliancy; such an arrangement would be preferable to the cumbersome fittings which were regarded as necessary for the diffusion of light from the gas-filled lamps at the present time. This problem, however, rested largely in the hands of glass manufacturers, who were rather difficult to move in such matters. The solution to strive for was the provision of a compact diffusing device fitting closely round the gas-filled lamp. At the present time it was almost impossible to get any illuminating glassware at all, notwithstanding the great variety of designs that Mr. Willcox had shown.

Mr. Willcox was a strong advocate of total indirect lighting, but it was gratifying to see that in the paper the author had illustrated alternative methods so that he now had several strings to his bow. The holophane reflector-refractor type of fitting offered promise for the future and its development would be watched with interest.

Mr. S. B. LANGLANDS said that after it was found that Glasgow was more or less immune from attacks from the air, the lighting restrictions were relaxed, they put gas-filled lamps into the arc lamp globes, and in spite of the globes being smeared, a very satisfactory result was obtained. With regard to the question of vibration, he had used the lamps attached to the stay wires of the overhead tramway system, at a junction. A cluster of five lamps was used in series and the results all round were very satisfactory. He personally thought there was a great future for the gas-filled lamp in connection with street lighting, and he hoped they would be able to eliminate that forest of cast-iron pillars which had come into existence in consequence of the introduction of arc lamps. He was aiming at a suspension gear attached to the sides of the buildings. Anything more hideous than the cast-iron pillars now used he could not imagine, especially in cities where there were beautiful buildings. He had also been able considerably to improve the lighting of a portion of an art gallery where there was a large glass cupola roof which provided the source of daylight. He made use of the same principle by putting a number of lights under the cupola and filtering the light on to the pictures through a tinted gauze screen. The effect was beautiful, but he had to refuse to apply it to the whole of the art gallery on account of the cost.

Mr. H. J. CASH (President of the Electrical Contractors' Association) said that the example of diffused lighting shown by the author in which the lamps were concealed in shells on pedestal columns although not new as regards interior lighting, had suggested to him the idea that it might be possible to apply the same principle to the lighting of new streets such as the approaches to the new bridges over the Thames or rebuilding on the lines of Kingsway, etc. Could not the lights be concealed on the facades of the buildings, the necessary downward reflection being obtained by utilising the under side of the cornices of the buildings, thus avoiding the unsightly forests of iron posts to which reference had been made? With the high efficiency of gas-filled lamps the extra consumption should be largely set-off by the saving in first cost and upkeep of the iron posts.

In his view the advent of gas-filled lamps was of the greatest assistance to the electrical contractor. In regard to interior lighting of large floor spaces the problem of obtaining a sufficient distribution had resulted in the past in the adoption of either a very large and unsightly number of small units on very long suspensions in order to bring the source of light near enough to the part to be illuminated; or alternatively, a smaller number of large clusters which for the same illumination involved extravagant expenditure in current. This difficulty was solved by the modern, efficient lamp which allows larger single units to be used without loss of economy and the long suspensions to be done away or materially reduced in number.

In regard to interior domestic lighting the problem in the past was that the client wanted the source of light shaded, whereas the illuminating engineer had to provide more light than was otherwise necessary in order to allow for the heavy loss of 60 to 70 per cent. due to shading. This problem was also solved by the fact that the gas-filled lamp demanded reflectors and when so fitted was still the most economical form of lighting, so that the work of the lighting contractor was greatly simplified in that he was now at one with his client on the subject of shading, instead of at variance as heretofore.

Mr. A. CUNNINGTON, referring to the point raised by Mr. Cash, said they must not rush to the conclusion that the adoption of large units would solve all the problems connected with lighting. There were conditions frequently occurring which would be adverse to the use of single units. Very often the spacing of lamps was limited by what had been done before the lighting engineer was called upon, and the question of whether in the particular circumstances it would be efficient to go to work in this way had to be considered. An example of that was the aeroplane factory shown in one of the slides, where there was a large floor space between the benches. The illumination appeared to be practically uniform over the whole place and he could not help thinking that if there was sufficient light on the benches there must be too much light on the floor. It did not seem to be sound illuminating engineering to give as much light on the floor as on the benches. At the same time, he agreed that the cost of maintenance was reduced by having to look after a few lamps instead of a large number of small units.

In this connection, he was not at all sure that the increased efficiency of these high candlepower units would always compensate for their deficiencies. The lower consumption of current was important, but there was also the cost of replacement to be considered. This had to be set against the cost when working with a larger number of small units. On this latter point it might be better to put in five 300 watt lamps than three 500 watt lamps as the former might allow of putting in a switching arrangement by which a certain number of the lamps could be switched out when not wanted. If Mr. Willcox's advice always to put in the largest unit was followed, there would be waste, as the candlepower could not be sub-divided and would have to be used at all times whether it was wanted or not. He complimented the author on the amount of useful information given in the paper, especially the tables giving lumens per watt for the various lamps, and asked that the efficiencies should be given as a total, *i.e.*, including the globe or diffuser. It would be seen that in the case of diffusing glassware the efficiency was low and such units should only be selected for appropriate conditions, as, for instance, interiors. In some circumstances diffusing glassware got very dirty, was often difficult to clean, and so became very inefficient.

Mr. A. C. CRAMB (Borough Electrical Engineer for Croydon) remarked that in street lighting it was very important that the distance between the lamp holder and the centre of the filament of the lamp should be standardised as completely as possible. With the class of labour used for the maintenance of street lighting the men would not as a rule pay attention to such matters as the correct focussing of lamps.

In street lighting it was also desirable to reduce the problems to the simplest form. He had been struck by the great variety of fittings which Mr. Willcox had illustrated. No doubt this variety was useful as an indication of stages of progress, but in the future it would certainly be desirable to concentrate on a smaller number of fittings and produce something eminently suitable for street lighting. Such standardisation would make it possible to produce good fittings at a much lower cost. At present there were a dozen or more designs available, but none of them could be regarded as entirely satisfactory. The question of the distribution of light available for street lighting was of great importance. Seeing that the amount of light that could be allotted to streets was still relatively small, he thought the aim should be to direct the greater part of the light into the road, where it was mainly needed, rather than on the surfaces of buildings.

Mr. H. W. COLE said that Mr. Willcox had rightly emphasised the higher efficiency and better conditions obtainable from the high candlepower gas-filled lamps. At the same time he thought that there were many cases in which there was still a need for the smaller units. One point that had struck him, as one of the pioneers of indirect lighting, was that a number of small units of a given total candlepower produced an impression of greater brightness than when the light was concentrated in a single unit. For example, he found a general impression that three 8 candlepower lamps gave a better illumination than one 32 candlepower lamp. No doubt this was due to some physiological impression received by the eye.

Mr. LANCASTER said that there was a general desire for fuller information from manufacturers regarding the life of gas-filled lamps. In his experience considerable variations were met with. Thus in one case, where two hundred 50 volt 300 watt lamps were used, the life varied from 129 to 16,300 hours. The average life was over 2,000 hours, but the lamps were 7% under-run. In a second case, when 100 volt lamps were used, the average value was also about 2,000 hours, the lamps being under-run 10% to 15%. During the war it had naturally been difficult for manufacturers to turn out lamps of the desired uniformity in this respect, but he hoped that the future would see an improvement. Any information that the author could supply on this matter, and also on the important question of the standardisation of the dimensions of lamps, would be welcome.

Mr. N. ARUNDEL agreed that it was most important that fittings should be specially designed for use with gas-filled lamps. A question that still presented some difficulties was the provision of adequate ventilation, and he was glad to see that several firms had been investigating the problem on scientific lines. *Added* :—While the discussion has dealt mainly with the practical applications and the distribution of light from gas-filled lamps by suitable fittings, one somewhat important point, the domestic applications of gas-filled lamps, has received little attention. The whiter colour of the light, which is preferable to that of the vacuum type lamps for the illumination of coloured objects, is here an advantage. It may be of interest to record one interesting effect I have observed that is apparently connected with the quality of radiation emitted. I have noticed that vases of flowers which have begun to droop in the course of the day may be revived if placed immediately under a gas-filled lamp; for example, a 100 candlepower lamp at a distance of 2—3 feet. The stems which have begun to sag stiffen and the flowers open more fully. I have not observed a similar effect with ordinary vacuum tungsten lamps. The effect, if confirmed, would seem to be of some interest to florists and seems to be worth consideration in selecting lamps for lighting a dinner table.

Mr. FREEMAN, referring to the lighting of the aircraft works illustrated by Mr. Willcox, suggested that in such a case it might sometimes be necessary for the positions of benches, etc., to be changed, in which case uniform lighting throughout the shop would be a great advantage. He thought that possibly Mr. Cunningham, in his remarks on this installation, had not given sufficient weight to this circumstance.

Mr. L. GASTER said that Mr. Willcox was to be congratulated on his timely and practical paper. Owing to circumstances over which manufacturers had no control, the development of the gas-filled lamp had not reached the stage it would doubtless have done but for the war. In adopting such lamps it was necessary to consider carefully whether, in view of the cost of maintenance, it was economical to use the lamp in all circumstances. At present, in the matter of renewing lamps which had failed prematurely, consumers had to depend a great deal on the goodwill of manufacturers. The life of some batches of lamps recently supplied had, in his experience, been far from satisfactory, but no doubt better results would be obtained in the future. He hoped that manufacturers would be able to attain a general improvement in quality and, if possible, a reduction in price.

A point of consequence was the standardisation of the positions of filaments in relation to the bulb. There seemed no necessity for the great variations met with in the length of bulbs in lamps of the same consumption and voltage. The drawbacks of such variations in dimensions were made evident when lamps in existing fittings had to be changed. In some cases the new lamp projected right out of the reflector, producing a glaring effect, in others the filament was located so deep inside it that the proper distribution of light was not secured. Some people were so much impressed by the inconvenience of these variations in bulb-length that they decided to avoid using gas-filled lamps altogether; in order to avoid such rash decisions it seemed desirable that the point should be looked into.

As regards the choice between large and small units, he agreed with Mr. Cunnington that it was not always advisable to adopt the largest sizes. If only one powerful light was used the whole area lighted by it was put in darkness in the event of a failure. Therefore, while the use of relatively large units had, as Mr. Willcox had suggested, some advantages, each case must be considered on its merits. Subject to the above limitation, the trouble in maintaining large units was less than when a larger number of small lamps were used.

With regard to street lighting, standardisation was an important feature, as Mr. Cramb had remarked. It was not unusual to introduce gas-filled lamps in fittings originally intended for arc lamps. Owing to the vibration of heavy traffic, lamps were apt to be broken and in some cases anti-vibration devices were necessary. He thought that the useful life of the lamps should be at least 800 hours, if any material saving was to be made with the present price of lamps and cost of energy. Some of the lamps he had installed had had a short and merry life. Subject to the anticipated improvement in this respect there was every reason to expect a wide field of usefulness for the gas-filled lamp, both for interior and exterior lighting, and in many directions their use would provide good scope for the efforts of the illuminating engineer.

Mr. J. S. Dow said that he found himself in general agreement with Mr. Willcox's remarks on the desirability of overhead lighting, and also on the objectionable practice of inserting gas-filled lamps in fittings originally designed for vacuum lamps. He noticed that in some recent installations in the United States, notably in one of the large shipbuilding yards, mounting heights even higher than those mentioned by Mr. Willcox, ranging up to 40 feet, were employed. In regard to street-lighting, he had seen several cases in the suburbs of London in which very powerful gas-lamps were installed unshaded; in these circumstances, and especially when single gas-filled lamps were introduced among vacuum lamps of relatively small candlepower, the effect of glare was very marked. He also observed a tendency to introduce gas-filled lamps in places where small candlepower vacuum lamps were previously used in couples at a low level, one on either side of a lamp-post, as an alternative to the arc-lamp up above. The use of gas-filled lamps at this low level needed special care, and he thought the lower half of the lamp should invariably be frosted, and, where possible, a reflector used over the upper half of the lamp. It was practically impossible to secure even illumination from lamps at this low level, and the best policy seemed therefore to acquiesce in uneven lighting, provided glare was avoided, and the transition from the bright illumination under the lamp to the lower illumination in the more remote regions of the street was gradual.

Mr. Geo. Wilkinson (Borough Electrical Engineer, Harrogate)—*communicated*:—I have read Mr. Willcox's paper with interest, and there are a few points I would like to emphasise. One thing that has always appealed to me as a waste of money is the use of expensive fittings for street lighting purposes. In the case of a gas lamp there is naturally justification for the use of tight-fitting globes and lanterns in order to protect the flame from the wind. But the incandescent filament is already enclosed in an air-tight glass bulb, and for years we have used in Harrogate no fittings whatever except the copper lamp holders under a Holophane reflector. Under these conditions the lamps seem to have longer lives. In the case of a gas-filled lamp we frost the bottom half of the bulb so that the eye does not see the intensely luminous filament. This system is eminently satisfactory, and entails no heavy outlay in lanterns and fittings. The introduction of prismatic shades or globes round the lamps inevitably curtails the amount of light issuing from the lamps and does not commend itself to me for outdoor work.

General lighting by artificial means has always proved more expensive than local lighting by small power lamps at the particular point where the light is required, and it remains to be seen whether the improved efficiency of the gas-filled lamp enables it to compete successfully with vacuum lamps, properly shaded, at local points. There is also one drawback to the provision of a general dead-level of illumination. In an ordinary workshop, well lighted by natural means, it will be found that although the general illumination is good, a piece of work that requires special careful examination is inevitably taken into the open-air to be scrutinised.

Now if the artificial illumination is uniform, after darkness sets in you will receive complaints that there are no facilities for examining work which, to ordinary eyes, needs special illumination.

Mr. A. WISE (*communicated*): Mr. Willcox's interesting paper on the use of gas-filled lamps brings to our notice several new features in the province of illuminating engineering. Mr. Willcox states that gas-filled lamps are unsuitable for direct lighting. This is rather a sweeping statement to make. Gas-filled lamps are now being made in candle-powers which approximate more closely the lower values in which the vacuum type Tungsten filament lamp has been made in the past. To put these lower candlepower units into a diffusing bowl would, in my opinion, counteract the increased efficiency which is obtained by the use of these lamps. Whilst, however, agreeing that lamps of say 200 watts and upwards should be diffused by a lower bowl surrounding the bulb, I think that discretion must be used in applying this principle to the smaller ratings. It is often quite sufficient, and certainly more economical to enclose the bulb in a reflector and simply obscure the pip end, provided proper attention is paid to the mounting height, spacing and design of the reflector.

Again, as Mr. Cunnington remarked, discretion must be used in fixing the mounting height of the units. It is not always practicable, and sometimes even undesirable, to install the lights at the maximum possible height. The example quoted by Mr. Willcox of an aeroplane factory so installed is possibly a case where this arrangement was quite suitable, but the majority of factories are limited in ceiling height to between 12 and 18 ft. and obstructions, such as overhead shafting and girder work, are usually the deciding factors. One of the greatest drawbacks of excessive height is the inaccessibility for cleaning purposes unless suitable raising and lowering gear is provided, adding to the cost of installation.

Mr. Willcox remarks that extensive distribution of light is unobtainable with a simple top reflector. As a matter of fact the immediate effect of placing a diffusing bowl below the lamp is to diffuse quite a considerable percentage of the direct rays of the lamp. The minimum size of the bowl is, however, limited by consideration of intrinsic brilliancy.

It would be interesting to compare the illumination curve obtained from the refractor band with that obtained from a properly designed extensive top reflector at say 100 ft. spacing. With the existing variation in different makes of gas-filled lamps, it would also be of interest to see what difference is made in the distribution curve obtained by varying the position of the lamp relative to the focal point of the refractor band. If accurate focussing is an essential factor in the correct usage of the band, very careful re-adjustment will be needed whenever a lamp is changed as otherwise the illumination will be seriously affected. Perhaps Mr. Willcox could furnish some information upon this point.

The question of the ventilation of fittings for use with gas-filled lamps seems to merit further discussion. For interior lighting, ventilation is, of course, quite a simple proposition; for exterior fittings the question is not so simple as it appears on the surface. The provision of a hole at the bottom and a few holes at the top of the lantern, the latter covered by a "lid," is, in my opinion, not efficient. This question is of considerable importance, especially with the higher wattage lamps.

Mr. F. W. **Willcox** made the following reply to the discussion :—

Mr. Harrison suggests that data for the various fittings should be given in complete form showing the efficiency in lumens, etc. This suggestion has my hearty endorsement. It has been my constant desire to present data for each fitting in such complete form that any and every question in problems could readily be answered. Unfortunately, the shortage of help, due to the war, has made it impracticable to carry out any such programme—but I plan to do so in the near future. American companies were regularly issuing such data for each fitting. I show herewith a copy of illuminating data sheet as issued by the American General Electric Company. A good amount of data on English fittings is already available—some of it published and in regular use and more will be published in due course.

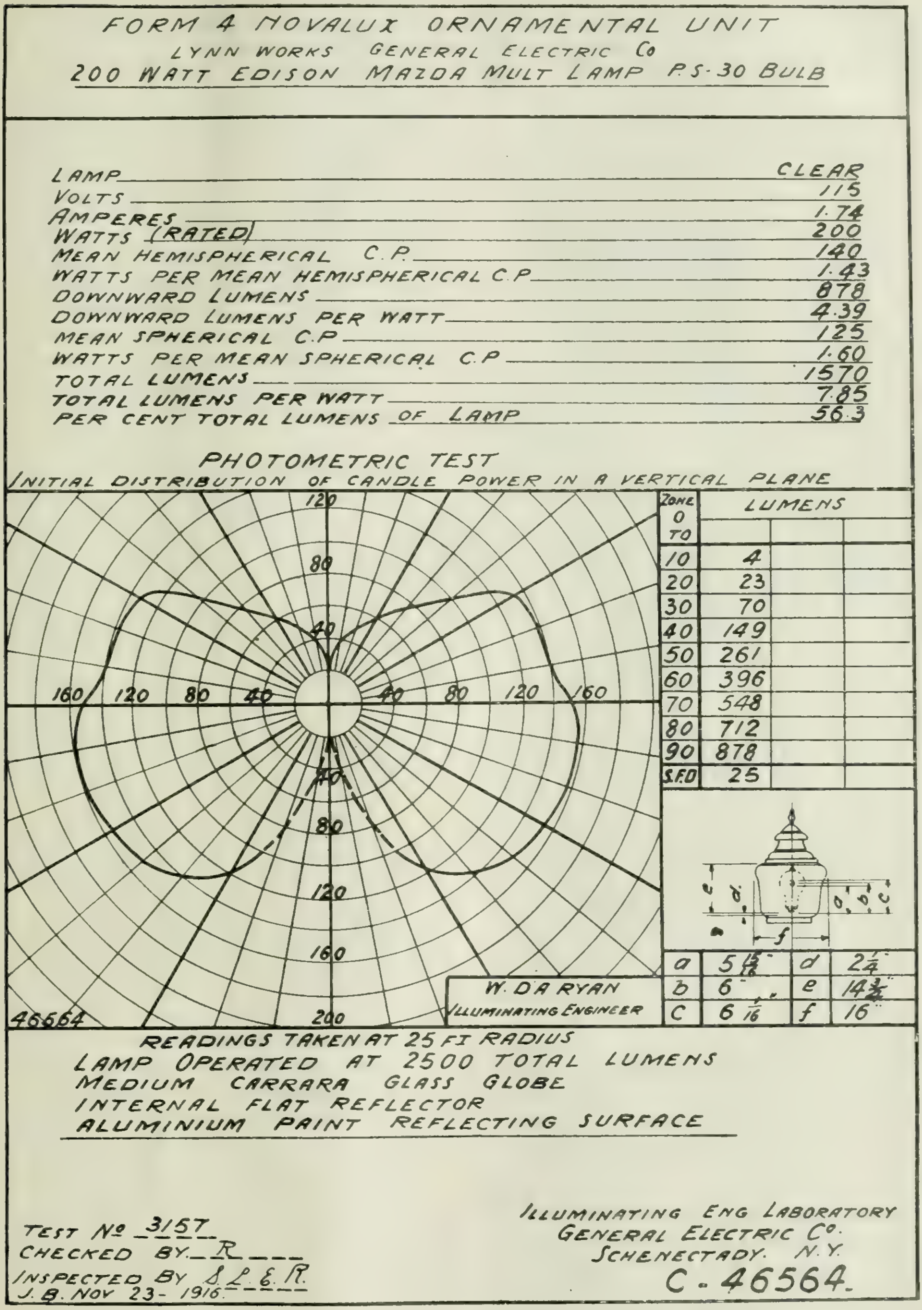
The actual luminous efficiency of the industrial types of reflectors described in the paper—*i.e.*, steel and vitreous enamelled reflectors—can be taken as 70 to 75 per cent. for some of the best designs. Mr. Harrison has wrongly interpreted the data for the reflector as shown in Fig. 32. The efficiency is very much better than the 22 per cent. figure he mentions, and I am at loss to see how he obtains this figure.

The American projection type of gas-filled lamps tested by Mr. Harrison were special lamps and the filament construction provided would not be desirable or justified as a standard construction giving the best life and service for regular lighting work.

The paper presented was intended to deal rather with the applications of the gas-filled lamp than the lamp itself, as Mr. Harrison and others seem to infer. If the paper had been devoted to the subject of the gas-filled lamp the treatment would naturally have been entirely different. It was not possible to cover such a subject as well as the real subject of the paper within the time and space permissible. The gas-filled lamp would require a full paper and evening to itself.

Mr. Harrison and others raise certain queries on the performance and service of the gas-filled lamp. On the matter of cost there is no doubt that the present prices of the lamps, like many other things, are too high. The war is responsible for this, but we can count on suitable modifications in due course to place these lamps on a more acceptable basis of economic costs. On the matter of life I can assure all that the evidence is that gas-filled lamps give a very satisfactory average life.—(N.B.—I say "average life," for it is only by the average life and performances that electric lamps, new or old, can be properly judged and compared.) Mr Lancaster mentions differences in life given by lamps in various cases. There is nothing abnormal in this as similar results might be given by carbon filament or ordinary metal filament lamps. The individual life of lamps varies considerably—some failing after a short life, many before and many beyond the average period of economic life. The full period of life could not be expected from every lamp, any more than that all the children born could be expected to reach the average period of human life. The trouble with users of gas-filled lamps is that they attempt to judge the lamp by individual failures, instead of by the true average of the lamps that survive. The facts are that the average life is well up to 800 hours and in many sizes run well over 1,000 hours. Speaking from one manufacturer's experience, I can say that the number returned under complaint of service forms an exceedingly small percentage of the total number sold.

Mr. Cramb mentions the importance of standardisation of lamp dimensions. It is agreed that uniform standards of bulb dimensions for the various sizes of lamps are seriously needed. The lack of bulb standards is, and has been, a great source of trouble in illuminating equipment and lighting work. Here, again, conditions of bulb-supply due to the war are largely to blame. I can only give the assurance that the lamp manufacturers fully realise the needs of the present situation and are taking steps to correct it. In the near future, the bulb dimensions will be made of a uniform standard for each wattage size and, further, the light-centre position (filament centre) will be standardised.



FORM 4 NOVALUX ORNAMENTAL UNIT
LYNN WORKS GENERAL ELECTRIC Co
200 WATT EDISON MAZDA MULT LAMP P.S-30 BULB

LAMP	CLEAR
VOLTS	115
AMPERES	1.74
WATTS (RATED)	200
MEAN HEMISPHERICAL C.P.	140
WATTS PER MEAN HEMISPHERICAL C.P.	1.43
DOWNWARD LUMENS	878
DOWNWARD LUMENS PER WATT	4.39
MEAN SPHERICAL C.P.	125
WATTS PER MEAN SPHERICAL C.P.	1.60
TOTAL LUMENS	1570
TOTAL LUMENS PER WATT	7.85
PER CENT TOTAL LUMENS OF LAMP	56.3

PHOTOMETRIC TEST
INITIAL DISTRIBUTION OF CANDLE POWER IN A VERTICAL PLANE

ZONE 0 TO	LUMENS		
10	4		
20	23		
30	70		
40	149		
50	261		
60	396		
70	548		
80	712		
90	878		
S.F.D	25		

a	5 15/16"	d	2 1/4"
b	6"	e	14 3/4"
C	6 1/16"	f	16"

W. D'A RYAN
ILLUMINATING ENGINEER

READINGS TAKEN AT 25 FT RADIUS
LAMP OPERATED AT 2500 TOTAL LUMENS
MEDIUM CARRARA GLASS GLOBE
INTERNAL FLAT REFLECTOR
ALUMINIUM PAINT REFLECTING SURFACE

TEST No 3157
CHECKED BY R
INSPECTED BY S.L.E.R.
J.B. NOV 23- 1916

ILLUMINATING ENG LABORATORY
GENERAL ELECTRIC Co.
SCHENECTADY. N.Y.
C-46564.

Illumination Data Sheet for Electric Light Fittings and Equipment.

Case shown—Ornamental Street Lighting Unit equipped with a 200 watt 115 volt Gas Filled Lamp.

Data Sheet as issued by the Illuminating Engineering Laboratory, New York, of the (U.S.A.) General Electric Co., Schenectady.

In respect to designs of glassware and fittings shown, I have to explain that a number are American patterns, which were necessarily included in a review of the subject because of the extensive use of gas-filled lamps and equipment in American lighting practice, which, during the past four years, has been undisturbed by the war restrictions applying in Great Britain. As Mr. Baker says it is at present difficult to get any glassware at all, but we must remember that we have just emerged from war conditions and that in time the glassware required of the designs illustrated in the paper and other improved designs will become available in quantity to satisfy demands. In justice to the subject it was necessary to include examples of glassware and fittings, even though they were not available at present in this country.

Mr. Cunnington and Mr. Gaster in their comments on the use of large units seem to be under the impression that I have advocated the invariable use of large units. I have not intended to lay down any such rule, but have attempted to show that large units can be employed to advantage in many conditions instead of a very large number of small units. Practically no case can be made out for a small quantity of one or two or more large units, but where there are a considerable number of lamps the use of large units is recommended, as generally desirable to avoid the multiplied forest of lamps and fittings required with small units.

Mr. Cunnington's and Mr. Wilkinson's fears about the economy of general overhead lighting can be allayed, as in the case of the aeroplane factory illustrated—the average illumination on the working plane obtained was over 3·5 foot-candles for an expenditure of only 0·18 watts per square foot, or practically 21 lumens per watt, which is a very efficient result indeed. The use of diffusing glassware does not cause the efficiency to be low as Mr. Cunnington states. Actually the loss is small and considered from point of visual efficiency or seeing power there would be a gain. Glassware should, of course, be kept clear just like windows. Neither can be dispensed with because they may get dirty.

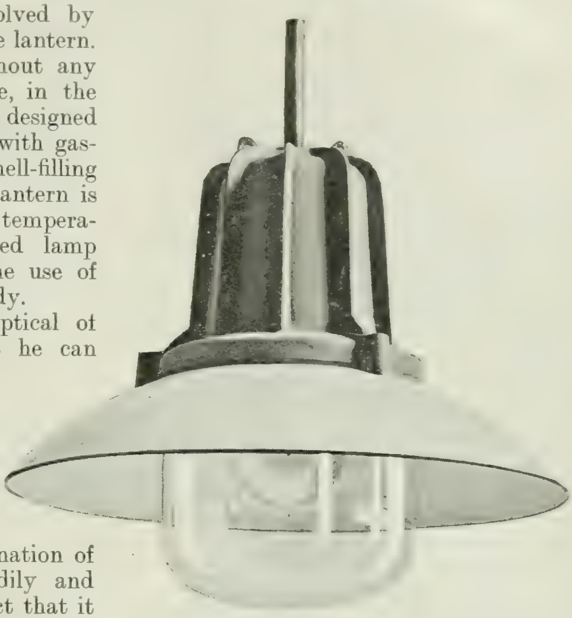
Mr. Cramb objected to the variety of fittings and expressed a wish for the production of an ideal type of fitting specially for street lighting. Unfortunately, a variety seemed unavoidable, and much of it results from the attempt to satisfy the ideas of Corporation engineers and the different conditions in the various cities and towns. The ideal fitting that everyone will accept is hardly in the range of practical expectations, although it is agreed that efforts to standardise and limit the variety of equipment deserve support.

Mr. Wise calls it a sweeping statement to say that gas-filled lamps are unsuitable for direct lighting. To say that gas-filled lamps are *utterly* unsuitable in *all* cases would be a sweeping statement, but I was careful to point out the conditions of unsuitability arising from the glare and brilliant rays within the direct line of vision. If these conditions be modified, as they may be, smaller ratings of lamps can be satisfactorily employed for direct lighting. In view of the opportunity, however, that these new lamps give to engineers and contractors to recommend and provide for the use of beautiful bowls in place of the ugly existing drop pendants and other direct lighting equipment, it does not seem desirable to support a case for the continuance of such old equipment.

Mr. Wise says it would be interesting to compare the illumination curve from a prismatic refractor band with that of a properly designed extensive type reflector on 180 feet spacing. Such comparisons have been very fully made and confirm the statement made by the writer in the paper that a pure extensive or wide angle distribution is not possible from a simple top reflector no matter what the design. You cannot have a distribution even approximating in extensive character to that given by the refractor. Test results are also available on Mr. Wise's other reference, *i.e.*, the difference it makes in the distribution curve by varying the position of the lamp from the focal point of the refractor band. I fear space is lacking for any more diagrams, but Mr. Wise can take it that even slight changes of position make a considerable difference and that careful focussing adjustment is necessary in all cases. This point is very important and should be emphasised.

As to the ventilation of fittings, Mr. Wise quite properly states that this is not a simple proposition to be solved by providing a few holes around the lantern. Fittings can be ventilated without any openings at all, as, for example, in the gas-tight and water-tight lantern designed by Mr. H. C. Wheat for using with gas-filled lamps during the war in shell-filling and explosive factories. This lantern is ventilated, and is kept at a safe temperature with a 300-watt gas-filled lamp hermetically sealed in it by the use of radiating fins on a cast-iron body.

Mr. Wilkinson is rather sceptical ot general overhead lighting, but he can be assured that it is quite generally recognised and accepted as the best practice, as, for example, in the State Codes for Industrial Lighting legislation issued by New York, New Jersey, and other States in U.S.A General illumination of suitable intensity can be readily and efficiently provided, and the fact that it is uniform, or, as Mr. Wilkinson says, "on a general dead level," is not a fault. Provided the degree of illumination be ample there will be no occasion for complaint after dark about lack of facilities for examining special work.



Hermetically sealed or gas-tight lantern for electric lamps of the gas-filled type. Employed in shell-filling and explosive factories during the war.

NATIONAL PHYSICAL LABORATORY ANNUAL VISIT.

THE usual visit to the National Physical Laboratory, on the occasion of the inspection by the Governing Board, took place on June 24th. In the departments of Engineering, Aeronautics, Metallurgy, Metrology and Physics many interesting demonstrations and types of apparatus were on view, illustrating the great development of the Laboratory's activities during recent years. The wind-channels in the Aeronautics Department and the William Froude National Tank, wherein various tests of seaplane floats were shown, attracted considerable interest. In the Heat Division of the Physics Department an apparatus was shown for determining the thermal conductivity of materials employed for the insulation of cold stores, and in the Electricity Department there were demonstrations of valves used with wireless waves, tests of the heating effect in buried cables, and tests on arc lamps for searchlights, as well as the apparatus, familiar to our readers, for testing radium painted dials.

Obituary.

SIR BOVERTON REDWOOD. Born April 26th, 1846—Died June 4th, 1919.

WE record with great regret the death of Sir Boverton Redwood, the eminent expert on petroleum, who passed away on June 4th. Sir Boverton, in the course of a long and distinguished career, had attained a unique position as an expert on oil and petroleum. He became associated with the oil industry as far back as 1870, and was responsible for many important inventions and researches. His services as an expert were in constant request in connection with large oil undertakings. In the years 1876—1877 he was associated with Sir Frederick Abel in an inquiry into accidents arising in the use of petroleum lamps, and subsequently —at the request of the London County Council—in preparing instructions for their manufacture and use.

He was for many years adviser on petroleum to the Admiralty, the Home Office, the India Office, and assisted many other public bodies, and was consulted on the framing of legislation on petroleum. He visited the chief oil-producing centres in the world at various times

Sir Boverton, however, took a wide interest in science and its technical applications. He acted as Professor of Chemistry to the Pharmaceutical Society for 40 years, he was a President of the Society of Chemical Industry in 1907-8, became a Fellow of the Institute of Chemistry in 1878, and subsequently a Vice-President, and had a long-standing connection with the Royal Society of Arts before whom he delivered a series of classic lectures on his special subject. He was also the first President of the Institute of Petroleum Technologists, and was largely responsible for the formation of this body.

No better instance of Sir Boverton's wide interests could be mentioned than his connection with the Illuminating Engineering Society, of which he was one of the original Vice-Presidents. At the inaugural meeting in 1909, he moved the vote of thanks to the late Professor Silvanus P. Thompson for his address, and he was present at the last annual dinner of the Society, held previous to the war. On many occasions he expressed his interest in the Society's work, and he sent an appreciatory message to this Journal on the occasion of its attaining its Tenth Anniversary last year.

Apart from his deep technical knowledge he possessed remarkable tact and *savoir faire*, and a genial and courteous personality. By his death the Society has lost one of its distinguished Vice-Presidents, and the world of science one of the greatest petroleum technologists.

THE JAMES WATT CENTENARY.

A LARGE public meeting representative of all branches of engineering and the chief scientific institutions of this country was held in the Council Chamber, Birmingham, on May 8th, for the purpose of considering a scheme for the celebration of the James Watt Centenary. The Lord Mayor, who presided on this occasion, explained that the proposed scheme included the endowment of a Chair of Engineering at Birmingham University and the erection of a Memorial Hall, which would also serve as a museum illustrating the work of Watt and his contemporaries. The scheme was further outlined by Mr. William Mills, Chairman of the Provisional Committee, was supported by Sir Oliver Lodge, Mr. W. W. Grierson, Sir Gerald Muntz, and Mr. Forest, representing respectively the Institutions of Civil, Mechanical and Electrical Engineers and others, and was carried unanimously. The commemoration is to take place in Birmingham on September 16th—18th. London, Glasgow, Greenock, and other cities specially interested in the work of Watt are also co-operating, and a movement has been inaugurated at Glasgow for the founding of a James Watt Chair of Engineering at the University.

Further particulars of the movement can be obtained from Mr. R. B. Ellis, Hon. Secretary of the James Watt Centenary Committee, Chamber of Commerce Building, New Street, Birmingham.

INDEX, June, 1919.

PAGE
Editorial. L. GASTER 137
Illuminating Engineering Society—
(Founded in London 1909.)
  Account of Meeting on May 30th 141
  New Members 141
  The Gas-filled Lamp and its effect on Illuminating Engineering, by **F. W. Willcox** 142
  Discussion :—HAYDN T. HARRISON—A. BLOK—C. A. BAKER—S. B. LANGLANDS—H. J. CASH—A. CUNNINGTON—A. C. CRAMB—H. W. COLE—E. W. LANCASTER—N. ARUNDEL—L. FREEMAN—L. GASTER—J. S. DOW—G. WILKINSON—A. WISE—Mr. F. W. WILLCOX (*in reply*) 161
James Watt Centenary, The 172
National Physical Laboratory, Visit to the 171
Obituary :– Sir Boverton Redwood 172
TOPICAL AND INDUSTRIAL SECTION 174
World Trade and the British Empire 173

WORLD TRADE AND THE BRITISH EMPIRE.

ON May 5th, a dinner was given by the British Commonwealth Union to Sir George Foster, G.C.M.G., Canadian Minister of Commerce.

Sir George Foster, in the address he delivered on this occasion, took a wide view of the relations between the mother country and the various Colonies and Dominions, referring first to the layering of tradition in this country. It was a good thing for a new people to come in contact with these traditions, and for the new to be mingled with the old. Sir George proceeded to refer to the boundless resources of the British Empire, which should play a great part in the reconstruction period and alleviate the financial burdens accumulated during the war. There were those who said, "What we want is world trade. We are not ready to tie ourselves up simply to British trade, big as we are." But it should be recognised that there was no way in which we could attain more surely to world trade than by developing our own boundless estate. During the war there had been great suffering and financial loss, but at the same time the efforts that had been successfully made had given a new consciousness of power. Canada had risen to the occasion, and had a new knowledge of her capabilities. In the future they would find Canada coming to the old country for business, and equally he hoped that Great Britain would multiply her efforts to secure business in Canada. Few people realised that Canada had to-day a larger area than the United States—greater than that occupied by thirty United Kingdoms—that within her boundaries fell one half of the fresh water area of the world. Those who entered the Canadian field must, however, co-operate in plan with people who knew the local conditions. There was in Canada a great opportunity for co-operation, organisation and united action for the benefit of the world.

TOPICAL AND INDUSTRIAL SECTION.

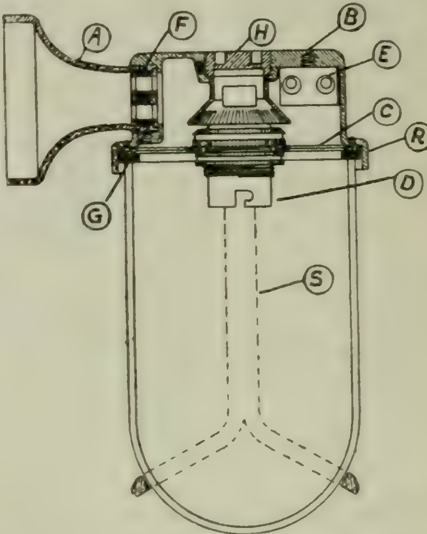
THE ROSS ANTI-VIBRATION DEVICE.

For use with Gas-filled and other Metallic Filament Lamps.

From time to time devices have been introduced for use with metallic filament lamps, and especially the smaller candle-power gas-filled lamps, in order to minimise the effects of vibration and prevent shock being communicated to the lamp and breaking the filament. There are various difficulties associated with these devices. For example, if supporting springs, being necessarily of stouter construction than the relatively delicate filament, are used, the conveyance of the vibration is very apt to cause rupture, while the freedom of movement which they allow may result in the lamp swinging under the influence of shock and wind-pressure and being broken by contact with the surrounding shade.

The feature of the Ross anti-vibration device, to which our attention has been drawn by the manufacturers (Engineering Supplies Co., Ltd., Lyndhurst Street, Thornaby-on-Tees, and Station Works, Allison Street in the same City), is that there is no connection between the outer fitting and the lampholder through which vibration may be conveyed. Yet the lamp is held rigidly in position and is claimed that all vibration and shock is effectively "smothered" before reaching the lamp and filament. The illustration shows the general nature of the device, which can be used either as a bracket or pendant fitting. The device is claimed to be mechanically strong and unaffected by heat or atmospheric conditions and well adapted to dissipate the heat from half-watt lamps. We are informed that the fitting has been tested under exceptionally severe conditions on board ship, under gun-fire and vibrations set up by a pneumatic hammer, and that lamps equipped with the device have successfully withstood the trial, although others not so equipped in the vicinity have been shattered.

Besides its primary use for lamps, the device is also recommended for use with various forms of delicate apparatus which are required to be used in positions where they are subjected to severe vibration.



General view of Ross Anti-Vibration Device.

A—*Supporting Arm.*
B—*Cast Body.*
C—*Anti-Vibration Disc.*
D—*Lampholder with Shade Ring.*
E—*Terminal Insulator.*
F—*Watertight Gland Rubber Washer.*
G—*Gland Washer.*
H—*Plug which exchanges position with supporting arm to convert fitting into Pendant.*
R—*Rubber Washer.*
S—*Brass Guard.*

ELECTRICAL ILLUMINATIONS AND PEACE CELEBRATIONS.

A new catalogue issued by the General Electric Co., Ltd., illustrates a number of designs for use in connection with the peace celebrations, each made of incombustible material and wired to receive lamps. The designs are mainly on familiar lines (Union Jack with rose, shamrock, and thistle, Britannia, Star of India, etc.), coloured reproductions appearing on the right hand pages of the catalogue. Particulars of "Pixielite" strip, colouring and fristing varnish for lamps, etc., are also included.

·ELECTRICITY· ·ACETYLENE·
The
ILLUMINATING
ENGINEER
·OIL· Edited by ·GAS·
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

The British Scientific Products Exhibition (1919).

Since the first British Scientific Products Exhibition was held last year there has been a vast change in the international situation—a change such as no one could have predicted at that time. The country was then still engaged in the most critical stage of the great struggle. Manufacturers, assisted by men of science, were striving to provide many essential commodities formerly derived almost exclusively from abroad. Scientific effort was also being expended on many novel problems arising from the war, many of which could only be referred to in very general terms. Throughout this period there was, however, little of the external competition which governs industry in ordinary times.

Now circumstances have entirely changed. The conflict is over and we are already grappling with the complex industrial difficulties which it was anticipated would follow the termination of war. Connections with other countries will gradually be re-established and as industrial conditions revert more nearly to those prevailing before the war this country will have to measure herself against the world and to meet the competition of other countries, many of whom, like ourselves, have learned valuable lessons during the war. The second British Scientific Products Exhibition, therefore, opened at a critical period in the industries of this country. Naturally, on this occasion the exhibits followed lines not dissimilar from those of the last Exhibition. They were, however, on a larger scale, and in connection with war problems there was much interesting information available which could not be disclosed last year. The descriptive catalogue is again a most interesting production, which should serve as a useful record for the future. The account of war work at universities and industrial laboratories is a useful feature. We trust that in a future edition it will also be found possible to include some account of the voluntary and valuable work of the chief scientific and technical societies, though we fully recognise the difficulty of dealing with this vast store of information within a limited space. We may add that the arrangement of the exhibits on this occasion was most convenient, and the frequent demonstrations a useful feature. As on the last occasion a series of lectures was arranged, including one by the author on "Scientific Lighting and Industrial Efficiency," which is summarised on pp. 188-190. It is interesting to recall that H.M. the King, on the occasion of his visit to the Exhibition, made a sympathetic reference to the importance of good illumination.

We were very glad to observe the sustained public interest in the Exhibition, which is thus becoming an annual event. At the present time there is a great need for the constant stimulus that such an exhibition affords; the need for scientific methods in industry should be constantly emphasised, in order to guard against the danger that, with the removal of the tension of the past few years, things will slip back into the old groove. The British Scientific Guild are to be congratulated on their enterprise in successfully promoting this second exhibition, and great credit is due to the Chairman of the Organising Committee, Sir Richard Gregory, and to Mr. Spiers, the Secretary, upon whom much of the work involved has fallen. The precedent established at the first exhibition of inviting the Circle of Scientific Technical and Trade Journalists to hold a meeting at the exhibition on the opening day was again followed, and an inspiring and appropriate address was delivered by Sir Richard Gregory. We hope that in future the exhibition will receive an increasing amount of support from manufacturers, which, apart from its scientific interest, affords a valuable medium for advertisement. The British Science Guild have shown great initiative in starting the venture; now that it has proved its worth, the Guild should not be saddled with an annual financial burden.

We cannot as yet foresee exactly the form which the exhibition will assume in future years, but there are one or two suggestions that might well be born in mind. In the first place we have yet to determine to what extent the progress of the past years can be translated into permanent industrial success. It remains to be seen how far supremacy gained during the war can be maintained under ordinary commercial conditions. We think, therefore, that it would serve a useful purpose if in future some comparison could be drawn, in regard to specific articles, between the products of various countries, so that the public can judge, by actual inspection of British and foreign articles, the degree of progress attained. Secondly, while the catalogues of the exhibition, it is true, enable some comparison to be drawn between progress in successive years, the actual exhibits are at present dispersed, and cannot be retained *en bloc*. There seems no reason why inventions and advances of outstanding merit in each year should not be placed permanently on record in a section of the Exhibition at South Kensington, designed to illustrate progress in the applications of science to industry. In this way we should gradually acquire a complete and consecutive record of progress which might be extremely valuable in years to come.

Illuminating Engineering Calculations and the Standardisation of Lighting Methods.

As the chief principles of illuminating engineering have become better established there has naturally developed a tendency to standardise methods of calculation, lamps and lighting appliances and details of spacing. One of the first steps in this direction was the now familiar device of using three standard types of reflectors (termed respectively " extensive," " intensive " and " focussing "), and assigning appropriate spacing ratios in order to obtain uniform illumination. In our present issue (pp. 192, 193) we reproduce a form of chart recently developed by Mr. A. J. Sweet in the United States, which was employed in connection with the lighting code of the State of Wisconsin. Similar charts have been prepared by various leading companies concerned with lamps and lighting appliances, but the present one is claimed to be exceptionally general in its scope.

In so far as these devices afford a general guide to practice in illuminating engineering we have always regarded them as helpful, but it must be understood that they have limitations. They depend on certain assumptions regarding the lamps and reflectors employed, and it is therefore very important that the latter should be of standard make, and that their distribution of light should be in practice what it is assumed to be in theory. There are also other factors that need to be borne in mind, such as the effect of variations in the shape of lamp-filaments or of their position with regard to the lamp-holder ; the latter especially has a marked influence on the curve of light distribution and at recent discussions of the Illuminating Engineering Society the importance of standardisation of filaments and bulbs was strongly commented upon. Other factors which affect the problem are the amount of reflection obtained from walls and ceiling, and the general structural features of the room lighted which may prevent close adherence to spacing rules.

All these considerations show the great advantage of being able to calculate illumination from first principles as a check on standard lighting data, and the paper read before the Society by Mr. W. C. Clinton in 1913 showed how closely illumination could be predicted in this way. When meeting novel problems in illumination, where past experience is of small assistance, the faculty of calculating from first principles is of special value. In any case, however, the calculation is founded on the curve of light distribution of the lighting unit employed ; hence the importance of this being accurately given by manufacturers.

The development of the series of industrial lighting codes now in operation in various of the United States of America seems to have given an impetus towards this form of standardisation. We notice in the *Electrical World* two recent articles by Mr. H. L. Cornelison and by Messrs. W. Harrison and H. H. Magdsick, which illustrate this tendency. The method adopted by the former involves the conventional assumption of a certain " utilisation factor " (*i.e.*, ratio between the lumens available on the working plane to total lumens yielded by lamps installed) of 0·45. It is here that local conditions, such as the shape of the room and reflection of surroundings, are apt to influence calculations, and it is therefore well to allow a liberal margin. Messrs. Harrison and Magdsick go a step further in the direction of stating standard illuminations for various processes. As a tentative step such specifications are of undoubted value pending confirmation by the experience now being gained.

Lighting and Traffic.

In the recent discussion before the Illuminating Engineering Society on "Street Lighting Reconstruction Problems," which we shall be dealing with more fully in our next issue, attention was drawn to the close relation existing between lighting and traffic and the need for considering the whole subject on a broad and uniform basis. It was pointed out that even within the London area there is no uniformity of treatment of public lighting, and that marked transitions, both as regards method of lighting and intensity of illumination provided, exist on arterial roads. During the war events have shown the advantages of co-operation by local authorities in dealing with public lighting restrictions on a uniform method. Now that the war is over there seems to be an opportunity for establishing better conditions, not merely in London, but throughout the country as a whole.

Since the date of this discussion public attention has been directed to another closely related matter—the present state of regulations relating to the lighting of vehicles. With the revocation of the restrictions imposed by Order during the war we are faced by the old pre-war conditions, according to which regulations are imposed individually by various local authorities, so that a motorist passing through an extensive area is almost bound to disobey the lighting regulations prevailing in some of the districts through which he passes. Such conditions are clearly inapplicable in the present day. They were open to less objection in the past when there was little motor traffic and each district had only to deal with local vehicles travelling within a small area. But they are quite out of date now. In the United States the great variations in the regulations for headlights in different States have given rise to much confusion and during the past few years strenuous efforts have been made to bring about greater uniformity and establish a code of rules which would be generally acceptable. We should now be in a position to profit by their experience and we should like to see a complete study made of the subject, in which the Illuminating Engineering Society would doubtless gladly lend their aid. We notice that the question of lights for motor cars is now to fall within the scope of the duties of the Ministry of Ways and Communications, and this body is therefore in a position to deal with the matter on a broad and scientific basis. Another item mentioned in this list of duties is the size and colour of signposts at dangerous corners, a point to which the London "Safety First" Council has given much attention, while the problem of providing suitable illuminated signs and notices, which is now being actively taken up in France, is yet another point deserving study.

Public lighting, however, is another matter which cannot be divorced from the study of traffic, for the assistance of which it mainly exists. Here, again, we meet the same anomaly of a problem which is of national interest being dealt with on individual parochial lines. Just as it is desirable for each district to require uniform conditions as regards the brilliancy and distribution of light from motor car headlights, so the proper illumination of highways for traffic demands the same treatment throughout the country. We should therefore like to see public lighting also brought within the scope of the Ministry of Ways and Communications, acting in co-operation with representatives of other bodies interested in the matter, such as the Illuminating Engineering Society, the London "Safety First" Council, and the Royal Automobile Club, as a central consultative authority from whom guidance might be sought.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE GAS-FILLED LAMP AND ITS EFFECT ON ILLUMINATING ENGINEERING.

(Further communicated remarks to the discussion held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m. on Friday, May 30th, 1919.)

In what follows we present two additional written contributions to the discussion of the paper on the above subject, read by Mr. F. W. Willcox before the Illuminating Engineering Society on May 30th :—

Mr. A. Dimmack (*communicated*) :—

The paper is very interesting, inasmuch as it gives a clear statement of the uses and advantages of gas-filled lamps in various spheres where the effects have been noted. No mention, however, is made of the candlepower of the smaller sizes, such as would be used in private houses.

The point mentioned by the author, that lamp cords, clusters, and flexible wires can be dispensed with where the situation is suitable for general lighting, is one of great value.

The author does not give any data about the life of the lamps, and it is not possible to obtain the relative costs for the same degree of lighting with gas-filled lamps as compared with vacuum lamps, unless this is known. For small units it is probable that the cost of the lamps is so great that an overall saving cannot be shown as compared with vacuum lamps.

There is no doubt that, for many purposes, indirect lighting gives very good results, but I think semi-indirect lighting has much to commend it, especially on the score of cheerfulness ; for tracing offices indirect lighting is not generally appreciated.

I entirely agree with the author's remarks with reference to the suitability of the gas-filled lamp for street lighting purposes, as a lamp of high candlepower, without the complications of an arc lamp, has long been wanted by every public lighting authority. As to the actual light given being better, that appears to be only a matter of diffusing by suitable shades. It is doubtful if the prismatic refractors suggested by the author would be entirely successful in the streets, as they would require washing frequently and well to retain their efficiency ; the simpler fittings are made for street lighting the more successful they are likely to be, bearing in mind that most of the cleaning has necessarily to be done from the top of a ladder. The focussing of the lamps if refractors were used would present difficulties to the type of man ordinarily employed on street lighting work.

Although I consider that it would be a step in the right direction to do away with clusters of lamps on street lamp posts, it would be a distinct disadvantage to have only one lamp, as if this failed for any reason, an important corner would be thrown into darkness, and although in London there are numerous lamps round important traffic points, it is not always so in the provinces. I think two lamps on a post for important situations would be satisfactory.

I do not think very ornamental lamp posts for street lighting are required; a simple effective post without too much detail work is far more in keeping, and adds dignity to the appearance of the street. I do not agree with the author that the present street lighting fittings for arc lamps appear ponderous and heavy in the streets; while in some cases over ornamentation has to some extent spoilt the elegant simplicity of the design of the lamp posts, in other, and I submit in the majority of cases, the street lighting by arc lamps has been very successful both from the points of view of appearance and utility. So far no other form of illumination for main streets has been able to approach anywhere near it, but the cost of maintenance is high and if the gas-filled lamp can replace the arc lamp, it will be welcomed by all lighting authorities as being simpler.

For factories there is no doubt that general lighting on a diffused system is the best, but odd lamps will always be required for local purposes.

The abolition of chandeliers from the centre of living rooms and offices would be a welcome innovation, but indirect lighting is likely to prove more expensive, light for light; roughly speaking, it appears to require twice as much light at the source to give the same result on the table.

My experience of shop lighting is that it is very difficult to persuade the proprietor to hide the lights; there is no doubt, from the illuminating engineer's standpoint, which is the more effective, but the shopkeeper usually likes to see a blaze of light. For classroom lighting it has been found by actual experiments that the eyesight of the students suffers with direct lighting, and that when the indirect system is substituted a very marked relief is obtained.

MR. E. W. LANCASTER (*communicated*): In addition to the question of the useful life of gas-filled lamps, referred to in the discussion of Mr. Willcox's paper, I should like to express the hope the future will see great improvements as regards uniformity. Any information which makers can supply on progress towards standardisation of dimensions of lamps will also be welcome.

There is no doubt that the advent of the gas-filled lamp will ultimately cause as great a revolution in the field of illuminating engineering as the demonstration of Sir Joseph (then Mr.) Swan at the Royal Institution in 1881 of the sub-division of electric lighting by means of his carbonised cotton filaments. These glow lamps then filled the very wide gap between the bat's wing and Argand gas burners and the electric arc lamp. Indirect lighting by means of inverted arc lamps and false ceilings was introduced in 1881, but did not become at all general for many years.

The effect of the gas-filled lamp on illuminating engineering will doubtless be very great, but it is most desirable that some simple rules in regard to their use should be drawn up by manufacturers. With a view to eliminating glare I would suggest that no unshaded gas-filled lamp should be used within the direct range of vision, that a 60-watt unshaded or unfrosted lamp should be at least 9 ft. high, and 100-watt lamps at least $10\frac{1}{2}$ ft. high, and so on proportionately for higher powers. The use of large units has been recommended, but this should not be done indiscriminately, and great care is necessary to secure uniformity of illumination. I may mention, for example, the case of a shell factory which installed sixty 500-watt lamps, in porcelain-enamelled reflectors of a concentrating type, at a height of $11\frac{1}{2}$ ft., and with a spacing distance of 18 ft. The filament was exposed in every direction and the lighting was uneven, the illumination being excessive for machines immediately under the lamps, and many shadows visible on intermediate machines. Ultimately the arrangement was altered, the area being divided into 10 ft. squares, with 200-watt lamps used at a height of 10 ft. The result was a great improvement, which was much appreciated by the women workers, who said that "last night was the first night on which they had gone home without a headache." Output was also beneficially affected, and the method was subsequently introduced throughout this and other similar works under the same control. This is probably only one among many instances in which gas-filled lamps have at first failed to give satisfaction because of the incorrect method of use.

While gas-filled lamps with appropriate appliances controlling the light can be used to meet almost any problem in artificial lighting, there are instances in which difficulties are met. I recall the exceptional case of a very large works with bays 90 ft. wide, in which an illumination of 1·75 foot-candles was provided from a height of 74 ft. and over. This was obtained by the proper spacing of 500 and 1,000-watt gas-filled lamps and reflectors, fixed at 75 ft. 6 in.

Mr. Willcox has pointed out the difficulty of securing an extensive distribution curve with the zig-zag filament. There is, however, no difficulty in obtaining a 2 to 1 distribution with the lamp mentioned and a Holophane reflector.

As regards the avoidance of glare, on which Mr. Willcox rightly laid stress, it is absolutely necessary that bare lamps should be entirely avoided, except in special cases when they can be effectively used at a great height. If manufacturers would adopt some simple means of educating the public to avoid glare, for example by printing simple rules and recommendations on wrappers supplied with lamps, this would be of great assistance to illuminating engineers and would gradually accustom people to judge illumination by the appearance of the object illuminated instead of the apparent light given by the source.

The height of suspension should determine the candlepower or lumens of the lamp used, and the selection of reflectors and the appropriate spacing by the intensity of illumination desired on the working plane.

Finally, it is unwise at the present time to force gas-filled lamps up to their highest efficiency, and as the data I quoted at the meeting show, beneficial results can often be secured by slight under-running.

THE HISTORICAL DEVELOPMENT OF STAGE LIGHTING.

We note that the copies of the *Bulletin* of the New York Public Library for June and July, 1919, contain useful lists of references to books dealing with "The Development of Scenic Art and Stage Machinery," including lighting, and that the series is to be continued.

In view of the recent discussion of Mr. J. B. Fagan's paper on "The Art of Stage Lighting" before the Illuminating Engineering Society, we feel sure these particulars would doubtless prove of interest to some of our readers and especially to those who took part in this discussion.

The *Bulletin* is published by the New York Public Library (476, Fifth Avenue, New York), and the price of single copies is ten cents.

ILLUMINATION AND ARCHITECTURE.

In a recent paper on the above subject, read before the German Illuminating Engineering Society, Dr. H. Lux summarised the essentials of good lighting and their relation to architectural practice. As values of illumination he proposed: for general lighting at floor level, 1 lux; on landings and staircases, 5 lux; in rooms containing many workers, 10 lux. For actual working illumination 20 lux is desirable for rough work, 25—30 lux for reading and writing, 50—100 lux for fine operations, drawing, watchmaking, etc. Values should be increased by 50 per cent. if the material is of a dark nature (1 lux (Hefner) = 0·084 ft.-candles). Attention is also drawn to other essential points, such as avoidance of glare and severe contrast, elimination of objectionable shadows, etc., and the "point to point" and "flux of light" methods of calculating illumination are explained. A brief summary is also given of methods of determining natural illumination in interiors.

SOME TESTS OF GAS-FILLED LAMPS.

In the *Revue Générale de l'Electricité* for May 10th, Mr. H. Pecheux describes some experiments with electric incandescent lamps, having filaments operating in an atmosphere of argon. A question which was studied in special detail was the relation between the resistance of the filament when respectively alight on its proper voltage and in the cold state.

Some typical curves relating to current, pressure and candlepower are given. Of the lamps tested the watts per candle varied from 0·80 to 0·85, but this figure would have to be corrected to take into account the reduction factor (ratio of horizontal to mean spherical candlepower) for these lamps which was about 1·08. As is well known the candlepower of incandescent lamps can be relating to the pressure by a formula of the type $I=A\ E^m$, where I denotes the candlepower, E the pressure in volts, and A and m are constants. It is of interest to note that in a series of lamps m varied from 2·41 to 3·43. For filaments of perfect purity, it is presumed, A and m would be exactly constant. An interesting fact revealed is that the specific consumption (watts per candle) is appreciably greater (0·85—0·89) on alternating current than the value given above for direct current (0·80—0·85). At the same time the rate of increase of candlepower with rising pressure on the characteristic curve is less.

Tests demonstrate that the candlepower of lamps in general increases to a maximum and then falls. Thus in a typical case a lamp gave 22 candles initially, 23·4 after 170 hours, and 22·6 after 500 hours. Furthermore, it was found that on alternating current both the resistance of the lamp when cold, and the resistance when incandescent on normal voltage, diminished to a minimum during the first 250 hours and then increased again. The ratio of the resistance hot to resistance cold also first diminished and then increased, though the change in this ratio was relatively small. There appear, therefore, to be two distinct effects. The filament apparently undergoes some molecular change due to the successive heating and cooling, which diminishes its resistance, and this masks the increase in resistance which might be anticipated owing to electro-vaporisation. The ultimate increase in resistance is possibly attributable to slow crystallisation of the metal, which is favoured by the vibrations due to the alternating current.

STREET LIGHTING IMPROVEMENTS.

At a meeting of the London "Safety First" Council, held on May 9th, the Street "Safety" Committee reported the receipt of a letter from the Hampstead Borough Council, stating that the suggestions made by the London "Safety First" Council in regard to the dangerous conditions at the junction of Finchley Road and Adelaide and Hilgrove Roads had been considered, and that the borough council had given instructions for danger notices to be erected in the vicinity of the roads named and upon the street lamp at the spot in question. Also that the Street Lighting Sub-Committee would consider and report upon existing street lighting conditions and the possibility of improvement or standardisation. Upon the suggestion of the Committee it was decided to invite Metropolitan public lighting authorities, when able to increase street lighting, to give preference to omnibus and tramway routes, and to extend efficient lighting of entrances to side streets where they approach main thoroughfares.

SHIPPING, ENGINEERING AND MACHINERY EXHIBITION.

The Rt. Hon. Lord Weir of Eastwood has promised to open the Shipping, Engineering and Machinery Exhibition at Olympia, on September 25th next. It will be recalled that this exhibition was to have been held in the autumn of 1914, but was postponed owing to the war. The Exhibition is to remain open for three weeks.

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

(Held at the Central Hall, Westminster, July 3rd to August 5th, 1919.)

The second British Scientific Products Exhibition, organised under the auspices of the British Science Guild, was held at the Central Hall, Westminster, from July 3rd to August 5th, and again received influential support.

As was the case last year, the exhibition was well attended, and was visited by H.M. the King and H.M. the Queen. Last year the exhibition was in the nature of a novelty, devoted to progress made during the war. The 1919 exhibition, held after the termination of war, marked a new stage. In view of the cessation of hostilities more information could be disclosed on many scientific problems solved during the war. From now onwards it will also be possible to make a better comparison between progress in this country and in others. The exhibition is thus becoming an annual feature, and it is satisfactory to find that the public interest was maintained.

Descriptive Catalogue of the Exhibition.

The descriptive catalogue edited by Sir Richard Gregory, the Chairman of the Exhibition Organising Committee, was again a most interesting production, occupying 331 pages. It was divided into five parts, dealing respectively with (1) War Work at the Universities and other institutions, (2) Works research laboratories, (3) Industrial Research Associations, (4) List of selected scientific and technical books, and (5) Descriptions of exhibits. The list of books is conveniently classified, and contains particulars of the best known works (in English) on Illumination. The catalogue thus contains a great deal of information which should be most useful for future reference, supplementary to the account of the actual exhibits.

Meeting of the Circle of Scientific, Technical and Trade Journalists.

A meeting of the Circle of Scientific, Technical and Trade Journalists was held at the Exhibition on the opening day, by the invitation of the Organising Committee. Mr. L. Gaster (Chairman of the Circle), who presided, referred to the changed conditions prevailing since the holding of the last exhibition. At that time the war was still in progress. Men of science and manufacturers were endeavouring to solve problems arising from the fact that we could no longer obtain many articles in the past imported mainly from abroad. Now a new stage was being reached when we should have to measure ourselves against the rest of the world. In the period of recuperation from the losses of the war applied science should play a great part, and in order to hasten the recovery it was highly important that public interest in the possibilities of applied science should be sustained. The exhibition therefore had still a great field before it in making known what had been already done and in inspiring manufacturers to further efforts. The scientific and technical press would gladly co-operate in the effort being made to kindle a greater appreciation of the value of science. Mr. Gaster congratulated Sir Richard on the excellent catalogue prepared, and expressed the hope that in future (if it could be done without unduly increasing the bulk of this publication), some account would also be given of the very valuable work done by scientific and technical societies since the outbreak of war. In conclusion Mr. Gaster congratulated Sir Richard Gregory on the knighthood he had received, which they regarded as a well-deserved recognition of his services both in the scientific and the journalistic fields.

Sir Richard Gregory then gave an inspiring address, in which he referred to some outstanding scientific achievements on which fuller information could now be disclosed. He mentioned, for example, the important part played by meteorological science in enabling information to be gathered regarding the condition of the upper atmosphere, a matter of vital importance to aircraft. Similarly forecasts of surface atmospheric phenomena had been of great value in relation to gun-sighting and range-finding both on land and sea. The organisation of the medical service for the prevention of disease as well as the treatment of wounds had been a veritable triumph.

Sir Richard paid a well-deserved tribute to the work of the universities and other institutions whose laboratories had provided ideas for machines and munitions and had done so much to counteract past unpreparedness. The work of scientific societies had also been of the utmost value, but the field of work was so vast that it had been found impossible to include any adequate account of it within the space available in the catalogue.

Many of the inventions of the past few years had shown very strikingly how often discoveries have had quite unforeseen applications in the war. Among the most remarkable instances of this was the use of the rare gas, helium, as a non-inflammable and non-explosive gas for use in airships. Helium had a lifting power only 10 per cent. less than hydrogen, and its advantages for this work were very great. Helium was first identified spectroscopically as an element in the sun by Sir Norman Lockyer about fifty years ago; and was found by Sir William Ramsay to be present in the gas given off by certain rare minerals, on heating, twenty-six years later. At the outbreak of war it had only been obtained in minute quantities, but the Admiralty Board of Invention and Research had early initiated investigations with a view to its preparation in bulk, and, with the aid of Canada and the United States, the supply of this gas for the inflation of airships had become a practical proposition by the time the Armistice was signed. The methods used for liquefying helium and other gases had had a marked effect on the development of modern refrigerating machinery; liquid air and oxygen were now used by airmen when flying at great heights, apparatus for storing these commodities being exhibited at the exhibition. Thus in two different directions this research work on the rare gases had borne useful fruit.

Other examples of the application of research work in pure science to industrial and war needs were to be found in the development of the aeroplane, the principle of which was originated in Langley's early experiments, and in wireless telegraphy. The thermionic valve now used both for wireless telegraphy and telephony was based on principles discovered originally in the work of Sir Joseph Thomson and others on the electrical conductivity of rarefied gases. Telephonic transmission with such valves could now cover 60 miles, or even, under favourable conditions, twice this distance. Another example of combination of scientific knowledge with mechanical skill was furnished by the large range-finders exhibited, in which this country was well in advance of others. In these and other appliances it had been necessary to manufacture optical glass of a character previously obtained mainly from abroad.

Many other instances of the application of science to industry were to be seen in the exhibition. But as the recent report of the Engineering Trades (New Industries) Committee showed, there were still many things being imported from foreign countries (gear-cutting appliances and fine mechanics' tools, milk-testing appliances, white metal spoons and forks, balances and barometers, photographic apparatus, dividing engines and drawing instruments, etc.) which might quite well be manufactured in this country.

Sir Richard also quoted from an account given by the Hon. W. C. Redfield, Secretary of Commerce to the United States, of what is being done in that country to restore industry to a peace basis. Mr. Redfield attributed the industrial success of Germany largely to two causes, (1) the appreciation of science which underlay each industry and its application; (2) the training of the mind as well as the hand of the worker so that he should understand both *how* to do a thing properly and *why* that was the proper way. Neither in Great Britain nor in the United States had scientific research or vocational training been conspicuous in industry; but both were being introduced as expeditiously as possible in the latter country. During the war Great Britain had recovered much lost ground, but would lose it again unless the development of industry through science was made a national aim. There was a danger that, with the close of the war, industry would drift back into the old grooves, and in the present critical period it was necessary to do everything possible to increase production and enable this country to maintain a leading place in the markets of the world.

A vote of thanks to Sir Richard for his address was moved by Mr. Davis, seconded by Mr. Percival Marshall, and carried unanimously, after which Lt.-Col. W. J. O'Meara said a few words on behalf of the Exhibition Organising Committee, welcoming the scientific and technical press, and inviting their co-operation. The visitors then dispersed to inspect the exhibits. The Exhibition was formally opened by the Marquess of Crewe in the afternoon, at 2.30 p.m., when an address was given by Lord Sydenham.

LECTURES AND DEMONSTRATIONS.

In several respects the exhibits were more conveniently assembled at the Central Hall than on the occasion of the 1918 display, the grouping of objects on the ground floor basement enabling each section to be easily approached. A feature was the series of demonstrations by various exhibitors, those connected with wireless telegraphy attracting special attention, while in the basement there were demonstrations of gas and electric cooking.

During the afternoons kinematograph films of scientific and technical interest, dealing, among other matters, with aircraft construction, ordnance, the water-powers of Canada, wireless telegraphy, and telephony, and magneto construction were shown. There was also an excellent series of lectures, many of them illustrated, on such subjects as "Chemistry in Reconstruction" (Sir William Tilden), "Coal Conservation" (Prof. H. E. Armstrong), "Progress in Range-Finders" (Prof. A. Barr), "Explosives" (Mr. J. Young), "Progress in Aviation during the War Period" (Mr. L. Bairstow), "Applications of Science to Military Training" (Mr. H. Standish Ball), "Scientific Lighting and Industrial Efficiency" (L. Gaster). A summary of the latter lecture appears on pages 188–190.

THE EXHIBITS.

The exhibits were grouped in ten sections, dealing respectively with Mechanical Science, Physics, Textiles, Electrical Apparatus, Medicine and Surgery, Paper and Illustrations, Agriculture, Chemistry, Aircraft, Fuels and Metallurgy.

It is naturally impossible within the space available to do more than give a very general idea of these exhibits, more particularly those bearing on optics and illumination.

Mechanical Science.—Prominent in this section was the exhibit of Messrs. Hadfields, Ltd., which comprised many specimens of special steel, including manganese steels, "Galahad" rustless steels for cutlery, surgical instruments, etc., and special magnet steels. Of great historical interest was the original transformer constructed of low hysteresis steel. Other items included a 6 in. trench howitzer as used by the British Army. Steam turbines and accessory apparatus were shown by C. A. Parsons and Co., while the "A.B.C. Skootmota," shown by Gilbert Campling, Ltd., a motor-scooter deriving power from a 1½ h.p. motor, was a very light and interesting production, intended for short journeys but stated to have a speed range of 3—20 miles per hour. Other special devices included pumps, improved trolley-heads for overhead electrical systems, diamonds for glass-cutting and other purposes, and a variety of testing apparatus. Of special interest are the optical projection devices for testing formed or shaped work, gauges, threads, etc., some examples of which were shown by the National Physical Laboratory, G. Cussons, Ltd., and others.

Physics and Electrical Apparatus.—These sections, which included optics and illumination, contained much of interest. Allusion has already been made to the series of large range-finders and periscopes shown by Barr and Stroude, which formed a conspicuous object. There were many examples of optical and other glassware. Optical and science lanterns were shown by the British Laboratory Ware Association and Messrs. Chance Bros. and Co., Ltd., the Derby Crown Glass Co., and others, illustrated the various stages in the manufacture of optical glass of various kinds. The Edison Swan Electric Co., Ltd., showed the "pointolite" lamp, and various sizes of gas-filled lamps and lamps for miners, for medical work and motor-car headlights; gas-filled and other special lamps were also shown by the British Thomson Houston Co., Ltd. Mr. F. Harrison Glew had again a display of scintilloscopes and apparatus and instruments utilising radioactive self-luminous paint. Crookes "Anti-glare" glass (for protection against ultra-violet radiation) were shown by Melson Wingate, Ltd. Mr. Lionel Pearce had on view an interesting and compact form of lantern designed to produce a close imitation to normal daylight. The lantern makes use of an ordinary tungsten lamp equipped with special coloured glass which corrects the excess of red and orange rays and illuminates an area of 9 in. by 7 in. (shielded from surrounding light), with "artificial daylight." The apparatus is well adapted to enable a comparison of the apparent colour of a surface, by this and any other light to be made. It is pointed out that daylight itself differs somewhat in colour according to climatic conditions, and the period of the day or year, *e.g.*, a screen set to intimate clear January daylight will be bluer than one designed to represent June daylight. Various gas lamps and gas soldering apparatus were shown by the Tilley High Pressure Gas Syndicate, among these being the "soft ray" 1,000 candlepower lamp, using gas at high pressure, an indoor lamp giving 100 candlepower, a street lantern, and an outdoor lamp giving 200 candlepower with high pressure oil vapour.

In the Electrical Appliances Section the Benjamin Electric, Ltd., showed a series of reflector fittings for use with gas-filled lamps, steel reflectors for local machine or bench lighting, well glass fittings, etc. Aldis Bros., besides various lenses designed for photographic, military and aircraft work, showed a form of daylight signalling lamp capable of signalling up to 12 miles in daylight. Another interesting novelty was the platinised surface mirror shown by Rheinberg and Co., who also showed special graticules, *i.e.*, devices for optically illuminating scales for aeroplane telescope sights and various precision optical apparatus.

A feature in the exhibition was the combined display of a number of firms under the auspices of the British Electrical and Allied Manufacturers' Association and similarly of various firms representing the British Optical Instrument Manufacturers' Association. It is stated that the latter organisation is about to publish an illustrated dictionary of scientific instruments in which all leading British makes will be represented. It is claimed that no other country can produce such fine astronomical telescopes of the largest size, while in many other directions, gun sights, microscopes, photographic lenses, binoculars, etc., results are quite equal to those of Continental countries, although hitherto the output has not been so great.

There was a good display of electrical instruments of all kinds, amongst which we may single out for special mention the electrically-driven gyrostats of Messrs. Elliott Bros., Ltd., made with an air-gap of only 1-100th of an inch. Electrical heating apparatus of various kinds, including the "Electro-vapour" non-luminous electric radiator, which depends on the heating of water in a closed vessel, hot-water heaters, soldering irons, etc., and electrically-heated airmen's clothing.

Marconi's Wireless Telegraph Co., with its exhibit of the wireless direction finder, short range wireless telephone sets, and $\frac{1}{4}$ k.w. low power telegraph sets for aircraft, attracted much attention, and the "Fullerphone," which has been very largely used by the British Army during the war, was also on show. Among other miscellaneous exhibits may be mentioned special micanite and other insulators, Dublilier mica condensers, magnetos and telegraph apparatus.

Chemicals, Dyes, Drugs, etc.—The section devoted to Medicine and Surgery contained many illustrations of drugs now manufactured by British firms, X-ray apparatus, etc., as well as typical examples of special researches of a physiological nature. In the "Chemistry" section, again, there were many synthetic chemicals shown which had only been made in this country since the outbreak of war, as well as glassware, filter papers and chemical laboratory accessories to which the same remark applies. Special exhibits illustrative of the development of coal-tar products were arranged by the South Metropolitan Co., and the Gas Light and Coke Co., and dyes, exhibited by British Dyes, Ltd., Levenstein, and others, were again a conspicuous feature.

Among the other sections, the aircraft display attracted much attention in the basement, where electric and gas cooking demonstrations were also given. The cooking display by the Gas, Light and Coke Co. was particularly attractive, and we may add that the use of concealed gas lamps over the ranges in this exhibit and also the illuminated fountain in the adjacent exhibit of the South Metropolitan Gas Co., were two of the few instances in which artificial light was effectively utilised for the purpose of display.

In the above account it has only been possible to give a very general account of this varied collection of exhibits, which was considerably more extensive than that collected last year. The British Science Guild are to be congratulated on the success attending this second exhibition, and we hope that it will continue to exert, year by year, a needed stimulus to the application of science to British Industries.

THE COLOURING OF ARC LAMP GLOBES UNDER THE ACTION OF LIGHT.

It is well known that lamp globes containing manganese gradually assume a purple colour under the action of light. As a result the transmission factor may be reduced in some cases to as low a value as 50—60 per cent. as compared with 90 per cent. for the new globe. The matter has been much discussed in the United States, and is revived by Mr. M. Luckiesh in a recent letter to the *Electrical World.*

The manganese is used in order to counteract the greenish tint otherwise noticeable owing to the presence of iron compounds. For interior lighting this tint would be objectionable, and here the liability to colouration is less. But in the case of globes used for street lamps, which are exposed continuously to full daylight and to the ultra-violet rays emitted by the source, Mr. Luckiesh suggests that it should be specified that no manganese is to be used. In such cases the slight greenish tint is not of great consequence.

SPECIAL TRAIN ILLUMINATION FOR GERMAN PEACE DELEGATES.

In the arrangements made for the return to Germany of the Count Brockdorff-Rantzau and his associates, prior to the signing of the Treaty, there is one point of interest. It appears that the delegates started for Germany by special train on Monday, June 16th, bearing with them the reply of the Allies, and that special additional lights were installed on the train in order that they might study the reply on the journey so as to be fully informed of the Allied intentions before they met the German Government at Weimar.

ILLUMINATING ENGINEERING SOCIETY, U.S.A.

Annual Convention

We understand that the next annual Convention of the Illuminating Engineering Society in the United States will be held in Chicago on October 20th to 23rd, when several joint meetings with other bodies will be arranged and a number of papers of exceptional interest presented.

SCIENTIFIC LIGHTING AND INDUSTRIAL EFFICIENCY.

By Leon Gaster

(Abstract of a lecture delivered at the British Scientific Products Exhibition on July 28th.)

The object of this Exhibition is to illustrate and encourage the application of science to industry, and this lecture deals with one special phase of the problem—the part played by illumination as a factor in industrial efficiency. There is no industry in this country which is not dependent on the use of light as a necessary element in efficient production. The tendencies during the war, such as the wider use of standardised methods of production and the larger proportion of work done by artificial light, rendered illumination of special importance. These tendencies will doubtless persist in the future in view of the importance of increasing the national production, and the extension of the "three shift" system, as recommended by Lord Leverhulme and others, will again involve special care in the provision of artificial light. This method can only be successful if lighting is scientifically designed for the work so that ultimately work by night may be no more fatiguing or dangerous than by day. In standardised processes, good lighting is of special importance because faulty illumination may cause defects at any point in the chain of operations and thus impede the process as a whole.

Industrial Illumination in Relation to Health.

It is proposed to deal with the value of good illumination successively in relation to health, safety and efficiency of work. The close relation between health and light has long been recognised. For many years the Home Office regulations have made special provision for the lighting of certain trades, where processes are necessarily carried on to a great extent by artificial light, where the danger of accidents is especially great, and where poisonous materials are worked with. Inadequate lighting, by encouraging want of cleanliness, inevitably increases the risks incurred. In those cases, such as mines, where work is done underground, the conditions are abnormal. Work under such conditions has given rise to special disorders, such as the affection of the eyes known as "miners' nystagmus," which has been largely attributed to faulty lighting conditions. While the illumination of mines is a difficult problem, there is much scope for improvement in this field. Night work in bakeries, which has also been the cause of industrial unrest, is another instance where proper artificial lighting is of vital consequence. Apart from special occupational diseases, disorders of vision caused by inadequate lighting, etc., it is obvious that poor illumination is also largely responsible for increasing industrial fatigue, since the effort involved is much increased when workers cannot see what they are doing. This matter should receive attention at the hands of the Research Board recently formed under the Department of Scientific and Industrial Research, which deals generally with conditions of work and industrial fatigue.

Industrial Illumination and Accidents.

Reference has frequently been made to the strong endorsement by the Committee on the Health of Munition Workers, of the drawbacks of inadequate lighting,* both as a cause of ill health and as a factor leading to accidents. For some years the part played by inadequate lighting in causing accidents has been increasingly appreciated. Many cases are on record of men working on saffolding losing their footing owing to faulty lighting, or failing to perceive loose planks, pits, etc.; of men failing to perceive approaching trains or trolleys; of workers becoming involved in moving machinery through failure to perceive its outlines; of persons carrying molten metal falling over irregularities on the floor and doing themselves injury. Stairways are a special case in point. Accidents may be caused not only by insufficient light, but by badly placed sources which dazzle the eyes instead of revealing the stairs to persons going down them. Full statistics of the relation between lighting and accidents have been published in the Report of the Departmental Committee on Lighting in Factories and Workshops. In particular it was shown that the number of accidents due to persons falling (a class of accident that is especially liable to be caused by defective lighting) is relatively much greater in the winter months, when artificial light is mainly used, than in the summer months, and also that the accident rate is much greater by night than by day, the increase in the case of docks being as much as 102 per cent. Confirmatory evidence relating to accidents generally has been supplied by Mr. R. E. Simpson in a recent paper before the Illuminating Engineering Society in the United States. In that country also the number of accidents in each month of the year has been tabulated and a similar preponderance revealed during the winter months. " Safety First " methods in the United States have done much to reduce accidents, and it is to be expected that the efforts of the newly-formed British Industrial " Safety First " Association will have a similar good result in this country. In particular a detailed study of the part played by defective lighting in causing accidents is much to be desired and a table showing how useful information on this point might be collected on a uniform basis was published in THE ILLUMINATING ENGINEER last year.*

---

* Illum. Eng., Jan. 1919, p. 35.

Mr. Simpson, in the paper referred to above, mentioned that the Travellers Insurance Company (U.S.A.) estimated that of 91,000 accidents in 1910, 23·8 per cent. were due to imperfect lighting. As a result of eight years' work this proportion has been diminished to 18 per cent., but even so it is reckoned that on the average the services of 108,000 men for one year were lost through preventable accidents. In this country Home Office statistics show that in 1914, 869 persons were killed and 147,045 injured in factories alone, apart from accidents on railways, in mines and in the streets, etc., and also minor " unreported " industrial accidents. In 1913 3½ million pounds were paid in respect of about 4,000 deaths and 477,000 disablement claims under the Workman's Compensation Act, and to this direct economic loss must be added the loss of the services of these men and the resultant disorganisation of industry.

The above data suffice to show that the claim for good illumination is fully justified on humanitarian grounds in the interests of health and safety, but it is to be noted that the claim on economic grounds is equally strong.

INDUSTRIAL ILLUMINATION IN RELATION TO OUTPUT AND EFFICIENCY.

For various reasons it is not always easy to trace the direct results, in the form of improved output, following the provision of better illumination. But there are quite enough data to show that good lighting is amply justified from this standpoint. Obviously inadequate lighting, by causing accidents which mean disorganisation, by impeding supervision of workers, by increasing the difficulty of rapid and efficient work, and by encouraging neglect of machinery, interferes with efficiency. It is folly to pay skilled workers high wages and install expensive machinery and to grudge the relatively small cost of proper lighting to enable both to do their work well. Many cases can be quoted in which work has improved when the lighting was put in order. Thus in an American leather factory the number of " rejects " diminished by 80 per cent. after the illumination was improved. Witnesses before the Home Office Departmental Committee mentioned cases in which the output was 12—20 per cent. higher by day than by night, and where the earnings of workers increased 11 per cent. when the lighting was improved. Mr. Franklin Thorp has stated that in the north workers tend to migrate to the better lighted mills, and it is common knowledge that when improved lighting is introduced into a section of a factory workers in other sections demand a similar improvement. Moreover, once better lighting is provided, neither management nor workers ever desire to return to the old conditions. One of the most remarkable series of tests on this point was that conducted recently by the Commonwealth Edison Company in Chicago. In one instance better illumination increased the output by 8—27 per cent. in various departments, and in other instances increases in output of as much as 30 and even 100 per cent. were noted. On the average an increased cost of lighting amounting to not more than 5 per cent. of the pay-roll would cause an increase in production of quite 15 per cent.*

---

* ILLUM. ENG., Jan. 1918, p. 17.

Statistics also show that the cost of light is almost invariably a very small fraction, sometimes less than 1 per cent. of the wages bill, and a still smaller fraction of the overall expenses. The cost of installation is also small in comparison with the benefits secured. Thus in the Ford Motor Works it was found to be under 3 per cent. of the entire first cost of equipment. That a definite relation exists between illumination and ease with which work can be done was illustrated by some experiments conducted at the National Physical Laboratory for the Home Office Committee, seamstresses being asked to state the illumination which was comfortable for working. Quite definite minima were thus revealed, an important point being that the product of the necessary illumination and the reflecting power of the cloth was found to be practically constant.

Industrial Illumination and Government Departments.

Previous to the war the governments of various European countries were already inquiring into the question of industrial lighting. In France a committee for the purpose was actually appointed, while in Belgium a movement in favour of the appointment of a similar committee was in progress. The war interfered with the completion of this work, but in Great Britain the Departmental Committee on Lighting in Factories and Workshops, appointed by the Home Office in 1913, pursued its labours in spite of the war, issuing its well known and comprehensive interim report in 1915. In this respect, therefore, Great Britain can claim to have been in advance of other countries. In the United States, however, progress in this direction has been rapid. The author brought the matter before the notice of the American Illuminating Engineering Society on the occasion of his visit to the States in 1912. Various difficulties were then recognised, but much progress has since been made. At the present time there are five States which actually possess legislative codes on industrial lighting, based largely on that prepared by the American Illuminating Engineering Society, while others have codes in prospect. Although the Home Office in this country has taken a very sympathetic attitude towards lighting during past years, and has done a great deal towards the encouragement of better industrial illumination, it has been rightly regarded as an anomaly that no definite general requirement of adequate industrial illumination existed in the Factory Act of this country. Accordingly one of the main recommendations made by the Departmental Committee was that general statutory requirements of adequate lighting should be made, and it is to be hoped that this recommendation will be carried into effect in the near future. Up to the present experience with the American industrial codes seems to have been highly satisfactory. Management and workers both recognise that improved illumination is for their common benefit and are anxious to receive guidance. Thus since the New York State code came into force in August, 1918, the number of orders issued for improvement in lighting and the proportion of compliances secured have steadily increased and throughout the whole period 50 per cent. of compliances have been secured. Features of interest have been the special arrangements made to educate inspectors in the requirements of good lighting and the full explanatory data which accompany some of the codes.

It is also highly probable that this question will now be receiving attention in other European countries and that in the near future industrial lighting will be the subject of international treatment.

---

* Illum. Eng., Oct., 1918.

PROGRESS IN LEGISLATION ON FACTORY LIGHTING IN THE UNITED STATES.

As our readers are aware legislation on factory lighting has been adopted by a number of the United States since the outbreak of war, and we are now in a position to summarise experience so far gained. In a paper read before the joint meeting of the Illuminating Engineering Society (U.S.A.) and the American Institute of Electrical Engineers on April 11th, Mr. G. H. Stickney reported that codes on industrial lighting had been adopted in Pennsylvania, New Jersey, New York, Wisconsin, and Oregon, and in several other States codes have been drafted and are awaiting adoption. Experience shows that quite 90 per cent. of manufacturers cordially desire to comply with the requirements. The chief difficulty has been merely to make clear to the layman what is required, and it has accordingly been found desirable to publish supplementary educational sections.

The codes agree in requiring adequate intensity, avoidance of glare, and proper distribution of light. Interpretation has been on a broad basis and the provision of sufficient illumination has been greatly aided by simple illumination-photometers. The definition of glare has presented more difficulty, and in the discussion Mr. Ward Harrison mentioned that he had been working for some time on an apparatus to indicate glare, termed a " glarometer." Professor Clewell advocated the organisation of suitable lectures and demonstrations for inspectors, and mentioned that the Museum of Safety in New Jersey contained various kinds of lighting systems, arranged for the purpose of enabling manufacturers and inspectors to see what sorts of installations are desirable.

Among those responsible for the interpretation and enforcement of codes, or for carrying them into effect, the following require education: (1) those who prepare the codes, (2) engineers and designers of lighting systems, (3) employers and managers, (4) employees.

Mr. John Vogt, of the New York State Labour Department, also emphasised the importance of education. He mentioned that inspectors attend a department school one day every two weeks and that the results of some 15,000 tests of lighting installations made by the Department are discussed for the benefit of inspectors. A very interesting table showing experience in securing compliance with the code was presented :—

Month.	Year.	Orders issued.	Compliances.
August ..	1918	35	27
September	1918	174	67
October ..	1918	611	88
November..	1918	546	156
December	1918	446	205
January ..	1919	608	517
February ..	1919	765	506
Total ..		3,185	1,566

Regular inspections made ..	56,236
Special inspections made ..	4,791

The table shows the growth in the work of the Department. Naturally due latitude has to be allowed in regard to time for improving installations but, as stated above, employers are receiving suggestions very cordially and a large number of compliances have already been secured.

Some discussion also took place on the variety of codes existing in different states, which are not quite identical. For the present, however, this variation is not entirely a drawback as it yields useful experience, and it was suggested that ultimately a common code for the whole country would be evolved.

A CHART TO FACILITATE LIGHTING CALCULATIONS.*

From time to time charts have been devised to facilitate calculations and predeterminations of illumination in installations of various kinds. The chief drawback to some of these is that they refer exclusively to special types of units and are difficult to apply in a general way. Assuming, however, that the nature of the lighting unit is fully understood, they are of undeniable assistance in many cases.

A chart which seems to have some useful features, designed by Mr. Arthur J. Sweet, is described in a recent issue of the *Electrical World*. This chart, it is stated, was included in the Industrial Lighting Code recently issued by the State of Wisconsin. It is adapted to a considerable range of good standard types of reflectors.

The chart is intended to apply to illumination measured in a horizontal plane 3 feet above the floor, and to horizontal illumination. Besides indicating the consumption for any given illumination the chart enables the corresponding mounting height to be determined. In practice the convenient height is affected to some extent by special local conditions. But in general the lamps should be hung as high as possible. This has two main advantages; it permits the use of wider spacing between lamps to secure uniform illumination, and thus reduces the number of units; and it keeps the lights out of the field of view, leaving a clear view of the room in which they are installed, and diminishing the possibility of glare.

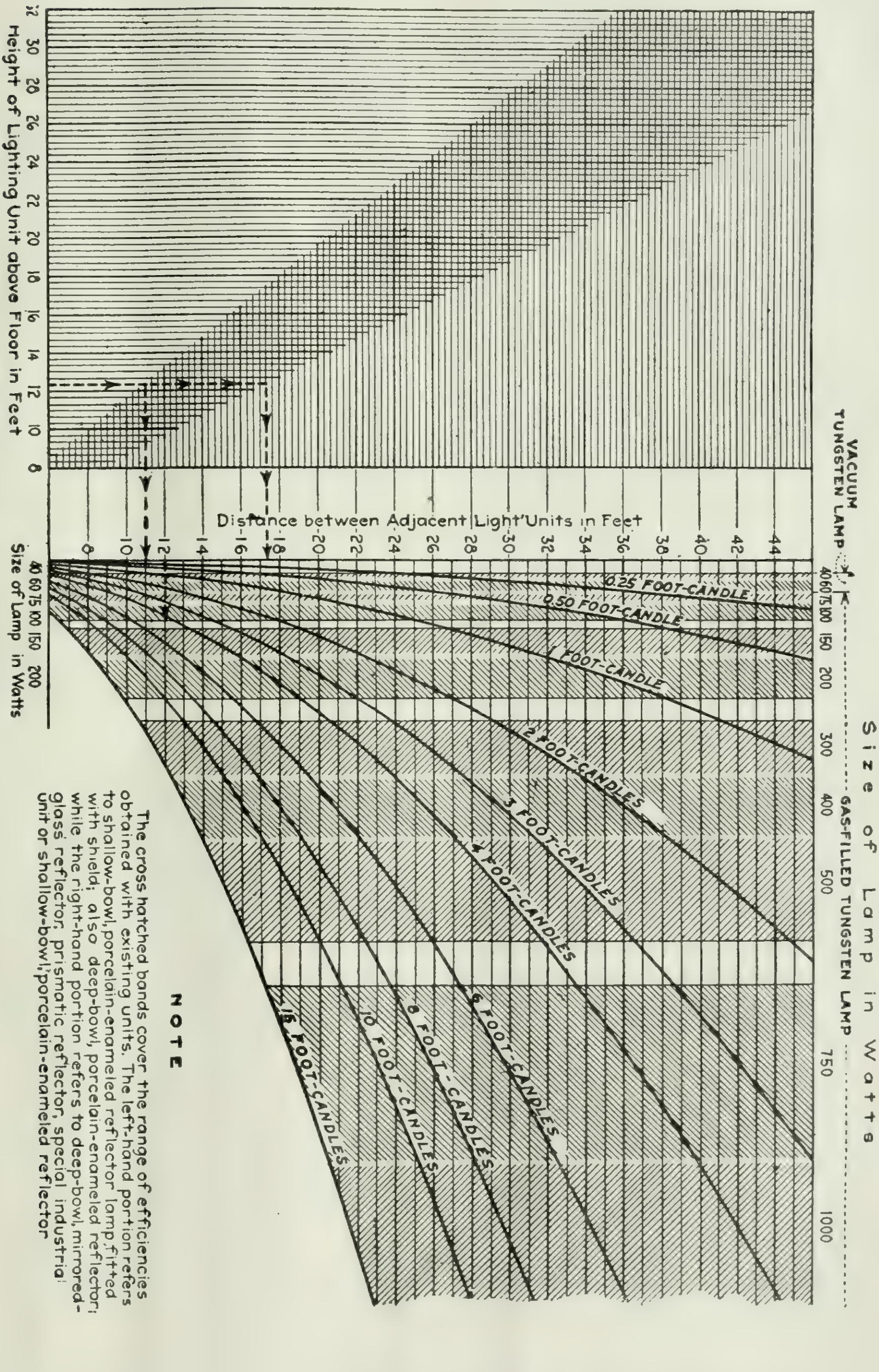
Assuming that the height of the unit has been decided (as near the ceiling as possible), the left hand portion of the chart enables the proper spacing between lamps to be determined. Thus assuming a mounting height of 12 ft. 4 in., the intersection of the vertical line with the first and last horizontal lines occurring at the boundary of the cross-hatched area in the diagram gives the closest and widest spacings that are desirable. The minimum value, in this case 11 ft., is best adapted to high illumination and should be approached where the work is of an exacting character; the spacing can, however, be modified, within these limits, according to the nature of the interior. In some cases it might be convenient to assume 11 ft. spacing in one direction and 13 ft. in the other. Let us assume an average spacing of 12 ft. Let us assume further that the work is such as to demand an illumination of 4 foot-candles. Following the horizontal line corresponding with 12 ft. spacing we find that the 4 foot-candle curve, on the right hand diagram, is intersected at a point indicating 100-watt lamps. A further indication is afforded by the fact that the intersection occurs on the right hand side of the cross-hatched area. This means that relatively high efficiency reflectors must be used; otherwise the illumination will fall below the amount specified. The band representing each type of lamp is of such a width that the left hand side indicates low-efficiency reflectors, the right hand side high efficiency units, and the intermediate area conditions of moderate efficiency.

It will also be noted that for units consuming more than 60-watt gas-filled lamps are assumed. The chart also allows for 30 per cent. depreciation in illumination due to deposits of dust on lamp and reflector, aging of lamps, etc. If the conditions are such as to make it likely that this deterioration will be exceeded, appropriately larger units should be used.

As mentioned above the chart refers to illumination in a horizontal plane, 3 feet above the floor. This is the most important factor for most operations, but

---

*Abstract of an article in the *Electrical World*, April 19th, 1919.



NOTE

The cross hatched bands cover the range of efficiencies obtained with existing units. The left-hand portion refers to shallow-bowl, porcelain-enameled reflector lamp, fitted with shield; also deep-bowl, porcelain-enameled reflector; while the right-hand portion refers to deep-bowl, mirrored-glass reflector, prismatic reflector, special industrial unit or shallow-bowl, porcelain-enameled reflector

CHART TO FACILITATE THE DESIGN OF LIGHTING SYSTEMS in some cases vertical illumination must also be considered. The ratio between illumination in a vertical and horizontal plane depends (a) on the position of light units, *e.g.*, how far they are in front of the working surface, and (b) on the type of reflector employed. The first condition will naturally vary in each installation and no precise rule can be given. But so far as the type of reflector is concerned the following table is given :

APPROXIMATE RATIO BETWEEN THE VERTICAL AND THE HORIZONTAL ILLUMINATION.

Type of reflector.	Vertical illumination as per cent. of horizontal illumination.	Correction factor to be applied to chart if used to determine vertical illumination.
Deep bowl prismatic glass reflector ..	100	1·0
Shallow bowl porcelain-enamelled metal reflector	70	1·4
Deep-bowl mirrored glass reflector	60	1·7
Shallow bowl porcelain-enamelled reflector ; lamp fitted with shield or cap ..	55	1·8
Deep bowl porcelain enamelled metal reflector	50	2·0

PROGRESS IN ELECTRIC LIGHTING IN THE UNITED STATES DURING 1918.

In a recent issue of the *General Electric Review* (U.S.A.) some particulars are given of developments in the electric industry during 1918, some data on lamps and fittings being included. During 1918 approximately 175 million incandescent electric lamps were sold, an increase of five million (3 per cent.) over the previous year ; of this number only 10 million were carbon filament lamps. Of the 165 million tungsten lamps sold it is estimated that about 16 per cent. were of the gas-filled type. During 1918 the number of gas-filled lamps increased by 32 per cent. as compared with the previous year, and owing to their greater price they probably were equivalent to about 50 per cent. of the total value of lamps sold.

A diagram is presented showing, in a very striking manner, how the sales of carbon filament lamps have progressively declined since 1907, when metal filament lamps were first commercially introduced. Equally striking is the great increase in the number of lamps produced since the outbreak of war. In 1913 the number had reached approximately 100 million, which fell to about 85 million during 1914. But from that year onward the increase was very rapid, so that during the period 1914-1918 the number has approximately doubled. Sales of tungsten filament miniature lamps (which are not included in the above figures) reached 80 million in 1918, practically all these lamps being required either for flashlight torches with dry batteries or for automobile lighting.

Several new lighting fittings are also illustrated. One of these is a canopy type fixture enabling a 10½ in. band Holophane prismatic refractor to be used with a gas-filled lamp. This was first installed on the Hog Island shipyard where a very large area had to be illuminated to facilitate night work. A modification of this type coppered and silvered over half the globe is also shown, this type being of special value where large vertical surfaces have to be lighted. There is also a projector type of unit, equipped with silver-plated reflectors giving a highly concentrated narrow beam ; this is useful in cases where, owing to the passage of cranes, etc., lighting units have to be spaced as high as 40 feet above the bays they illuminate. An illustration is given showing the application in the Hog Island Shipbuilding Yard of floodlighting projectors to facilitate night work.

Other developments mentioned include the new incandescent projection lamp for cinematograph work which has been previously described in this journal, the progress made in legislation relating to headlights, and the adoption of Industrial Lighting Codes by various States.

THE PRINCIPLES OF SCIENTIFIC ILLUMINATION.

A PAPER on the above subject was read by Mr. G. E. Webb, at a meeting of the Students' Section of the Institution of Electrical Engineers, held at Finsbury Technical College on May 9th, Mr. Leon Gaster presiding. There was a good attendance, and much interest was shown in the paper and subsequent discussion.

In the course of his paper, Mr. Webb explained the chief terms used in illuminating engineering, and discussed the nature of radiation from the chief illuminants, pointing out how small a portion of this total energy occurs in a visible form. He showed, also, how the point of maximum efficiency depended to some extent on the physiology of the eye, shifting somewhat as one passed from a high to a low illumination. The lecturer presented and described a number of typical modern photometers and illustrated his remarks on electric lamps by a series of interesting exhibits, including various types of "Pointolite" lamps, flame arcs, mercury vapour lamps, etc., and a gas-filled lamp equipped with special "artificial daylight" screen. Finally a summary was given of the chief principles to be followed in planning lighting installations, special importance being attached to correct spacing of light units, elimination of glare, and frequent attention to cleaning.

In the discussion which followed a number of students took part, and Mr. J. S. Dow made a few remarks on the possibilities of progress in illuminating engineering in the future, and especially the designing of photometers of a simpler and more convenient form.

Mr. Leon Gaster, in winding up the discussion, recalled that Professor Silvanus P. Thompson, the late Principal of the College, had been the first President of the Illuminating Engineering Society, to which he had rendered most valuable service. Mr. Gaster pointed out the great field for applied science in connection with illumination, dwelling especially on industrial lighting, to which, he hoped, reference would shortly be made in the Factory Act in this country. He looked to the students to carry on the good work. Now that so much information on illumination had been obtained there was a great field for their efforts. He congratulated Mr. Webb on his lecture, and on the interesting series of exhibits.

Votes of thanks to the Author, the Chairman, and the College Authorities terminated the proceedings, a considerable number of those present remaining to examine the lamps and photometers on view.

INDUSTRIAL ACCIDENTS.

IN a recent lecture before the Royal Society of Medicine Dr. H. M. Vernon mentioned that in every year over 1,000 workers in this country (not including miners) are killed; 100,000—200,000 suffer injuries sufficient to incapacitate them for a week or more, while over 2,000,000 suffer minor injuries. Dr. Vernon, commenting upon data obtained during the war in munitions factories, remarked that accidents were usually rare in the first hour of work but increased during the morning. It seemed doubtful if this could be attributed entirely to fatigue, but the fact that accidents had been found to be $2\frac{1}{2}$ times as numerous with a 12 hour day than when 10 hours was worked was doubtless due to workers becoming tired. Another factor which had to be taken into account in some cases was the extent to which alcohol was used.

Dr. Vernon added that accidents could be largely prevented by improving the lighting and keeping the factory at a suitable temperature and by the methods employed in the "safety campaign" developed in the United States, involving the formation of committees representing both employers and employed, to study accidents. By adopting such methods some well-known companies had reduced their accidents as much as 78 and 88 per cent., while at Port Sunlight, where safety methods were introduced in 1917, the number of accidents was reduced to 43 per cent. of those occurring in the previous year.

BENJAMIN FRANKLIN AS AN ADVOCATE OF DAYLIGHT SAVING.

It is curious how rarely any proposal that arises, even in the present century, can be said to be wholly new. Daylight saving, it appears, is no exception. The *Electrical World* has unearthed a letter sent anonymously by Benjamin Franklin to the *Journal de Paris* in 1784 in which he advocates the process of daylight saving with characteristic philosophy and humour.

"I was the other evening," he said, "in a grand company where the new lamp of Messrs. Quinquet and Lange was introduced and much admired for its splendour. But a general inquiry was made whether the oil it consumed was not in exact proportion to the light it afforded. . . . I was pleased to see this general concern for economy, for I love economy exceedingly."

Benjamin Franklin then goes on to describe how he went to bed with his head full of the project, and awoke in the early morning to find his room filled with light, not the light of the new lamp, but the natural light of day. This leads him to propose a measure closely resembling our modern daylight saving by which he estimates that between March 20th and September 20th 64,050,000 lb. of wax and tallow, of an equivalent money value of about 4½ million pounds, might be saved annually. In order to compel a general measure of daylight saving he proposed various steps, including a tax of a louis on every window that had shutters, no family to be allowed more than 1 lb. of candles per week, no coaches to be allowed to pass after sunset except those of physicians, surgeons and midwives, and that every morning as soon as the sun rose all the bells in each church should be set ringing and if this was not sufficient that cannon should be fired "to wake the sluggards effectually and make them open their eyes to their true interest." In addition to economy he emphasises the advantage to health of living for nothing by the pure light of the sun instead of "the smoky unwholesome and enormously expensive light of candles."

THE ROYAL SOCIETY CONVERSAZIONE.

At the conversazione arranged by the Royal Society on May 28th there were a number of interesting exhibits. Among these were a variety of novel appliances for testing recording altitude, acceleration, pitching and rolling (which could be studied by the variation in position of an image of the sun), and time-intervals by the regular flashing of a small incandescent lamp. The Cambridge Scientific Instrument Co. showed an apparatus for measuring the amount of gaseous impurities present in hydrogen by the alteration of resistance of a fine platinum wire, forming one arm of a Wheatstone bridge, in an atmosphere of this gas. Conversely the permeability of airship fabrics may be tested by measuring the rate of penetration of hydrogen from inside the envelope by a similar apparatus. Another piece of apparatus, showed by Professor J. T. McGregor Morris, utilised the unequal cooling of wires forming arms of a bridge to measure wind velocities.

The National Physical Laboratory showed several interesting exhibits. Amongst these was an arrangement for showing the production of tuned circuits with thermo-ionic valves, a musical note of varying pitch being excited in a telephone. The construction of the small lamps, some with grid operating in a vacuum, others in mercury vapour, was especially interesting, the effect on passing through the "critical" stage in the latter case being very clearly shown. The Laboratory also showed their optical projection method for measuring deviation from standard pitch in screw-thread or variations in dimensions of gauges, etc.

Among other exhibits of an optical nature may be mentioned the exhibition of the striations formed by electrical discharges in tubes of neon and hydrogen by observation of an image in a small rapidly rotating mirror, and some delightful astronomical photographs showing the Orion, Andromeda, Hercules and other constellations. The difference between galaxies of small stars and the continuous ring nebula of the constellation Lyra was especially well shown.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

THE G.E.C. "BUOY" HANDLAMP.

The General Electric Co., Ltd. (Queen Victoria Street, London, E.C.4, and Branches) have developed a handlamp for industrial purposes which is claimed to meet all requirements as regards convenience and long life. The new handlamp is known as the G.E.C. "Buoy" handlamp. It is illustrated below.

The base is of practically indestructible black insulating material weighing approximately 1¾ lb. The guard is of strong tinned steel wire and weighs practically nothing compared with the base, thus the latter, owing to its curvature and weight, will keep the lamp upright, however it is first placed. It will stand also on a gently sloping surface and can be used without any greater care than is commonly accorded material by unskilled labour in heavy industrial work. It is very compact, measuring only 8½ ins. long by 4½ ins. diameter, is provided with both a side hook and top hook, and has no weak appendages. It is shock-proof and easily grasped, and as it can be hung or stood anywhere, *both hands are left free*. It is stated that the lamp complies with the Home Office regulations with regard to hand lamps for use in factories, and it is anticipated that it will be found invaluable in workshop, garage, ship, store, or in any other industrial situation.

GAS AND THE HOUSING SCHEME.

An attractively got up catalogue has been issued under the above title by the Richmond Gas Stove and Meter Co., Ltd. As an introduction, quotation is made from the address of Lord Moulton when presiding at a recent meeting of the Royal Society of Arts, in which reference is made to the inevitable waste involved in heating by coal fires. The consumption of coal for domestic purposes in this country is estimated at about 36 million tons per annum and it is pointed out that this coal, if treated in the gas works, would yield 450,000 million cubic feet of gas, 20 million tons of coke, 400 million gallons of tar, and 450,000 tons of sulphate of ammonia for use as a fertiliser. In the catalogue useful forms of gas-heated cookers, coppers, hot-water circulators, geysers, etc., are illustrated. In view of the present scarcity and high cost of coal the use of gas for all such purposes naturally deserves the careful consideration of the householder.

THE WEDGE OPTICAL PYROMETER.

We have received from the manufacturers, Messrs. Cochrane & Co., Ltd., of Middlesbrough, an account of the Wedge optical pyrometer which depends on the extinction of light from the surface studied by means of a prism of red glass. It is pointed out that the temperature measurements based on radiation may involve either observation of total "black body " radiation or of light of a particular colour, red being selected in this instance as the most convenient tint to work with. Some account is given of experience with the instrument in use. In one case observations by different observers agreed within 5° C., and in some tests conducted by one of the largest gas companies the readings of individual observers were estimated to agree with each other and with the true temperature determined with the best available laboratory precision within 10 C. Attention is drawn to various factors that are apt to cause uncertainty in comparisons of pyrometric measurements, such as the fact of a mass of material not being in complete thermal equilibrium, so that the temperature registered by instruments at different points is not the same.

BRAZILIAN DELEGATES' VISIT TO THE GENERAL ELECTRIC CO., LTD.

On June 26th, two members of the Brazilian Commercial Delegation at present visiting England under the auspices of the Federation of British Industries were the guests of Mr. Hugo Hirst, Chairman of the General Electric Co., Ltd. The guests visited the Osram Lamp Works at Hammersmith, and were subsequently entertained to luncheon at Claridge's Hotel.

In the course of the proceedings Mr. Hirst referred to various opportunities he had had of coming in contact with Brazilian industries, and emphasised the advances which had taken place in that country, whose great potential resources would demand the co-operation of British manufacturers, especially in supplying suitable machinery.

The two Brazilian delegates, Dr. Souza Bandeira and Dr. Roberto Cochrane Simonsen, expressed their great interest in the information afforded during their visit, and hoped that the commercial interchange between Great Britain and Brazil would be improved as a result. One step which the Delegation would propose was the formation of an Anglo-Brazilian chamber of Industry and Commerce.

A NEW INDUSTRIAL INDIRECT LIGHTING UNIT.

The British Thomson Houston Co., Ltd., have introduced a form of industrial indirect lighting unit intended specially for industrial use (the " Icumfa " unit).

The unit is essentially an indirect fitting carrying its own ceiling in the form of a large steel reflector to redirect and diffuse the light. The lower half of the lamp-bulb is silvered, thus concealing the filament and reflecting its light upwards on the enamelled steel reflector, whence it is redirected on the working plane. In this way indirect lighting can be applied in factories where the system was hitherto impracticable owing to the darkness of ceilings or the presence of skylights, rafters, or overhead gear. These units are made in two sizes, the 24 in. for 150 and 200 watt, and the 30 in. for 300 to 1,000 watt lamps of the gas-filled type. The general nature of the fitting will be understood from Fig. 1, while Fig. 2 shows the distribution of light secured. The efficiency of the unit is stated to be comparatively high, and it is claimed that there are no upturned surfaces to accumulate the dust.

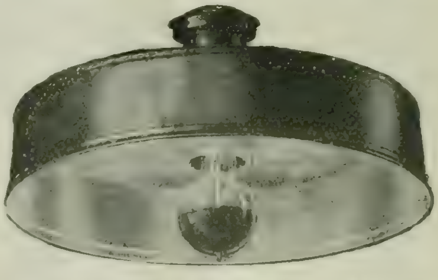


Fig. 1.—General view of " Icumfa " indirect fitting for industrial lighting.

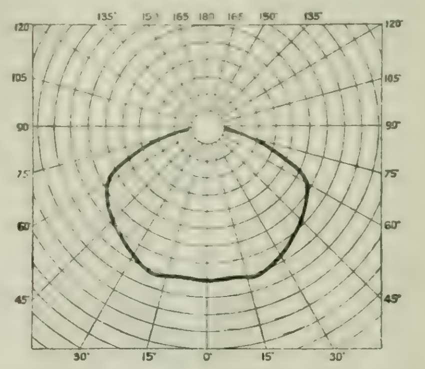


Fig. 2.—Curve showing intensive distribution given by " Icumfa " unit.

WANTED—A young graduate electrical engineer, who has had experience in illuminating layout. Permanent Position and good opportunity for advancement.—Apply to Box " A," The Illuminating Engineer, 32, Victoria Street, London, S.W.1.

INDEX, July, 1919.

PAGE
British Scientific Products Exhibition, The 183
Daylight Saving, Benjamin Franklin as an advocate of 196
Editorial. By L. GASTER 175
Electric Lighting in the United States, Progress in 1918 194
Gas-filled lamps, Tests of. H. PECHEUX 182
Illuminating Engineering Society—
(Founded in London, 1909)
The Gas-filled Lamp and its effect on Illuminating Engineering (continued discussion)—A. DIMMACK, E. W. LANCASTER 179
Industrial Accidents 195
Legislation on Industrial Lighting in U.S.A. 191
Lighting Calculations, A Chart for 192
REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED 199
Glasses for protecting the eyes from injurious radiations—Transactions of the Illuminating Engineering Society in Japan and the United States—British Journal of Ophthalmology—Pitman's Technical Bookshelf—Journal of the British Science Guild—Science and Industry in Canada 199
Scientific Lighting and Industrial Efficiency. By L. GASTER 188
Scientific Illumination, Principles of 195
TOPICAL AND INDUSTRIAL SECTION :—
G.E.C. "Buoy" Headlamp—Gas and the Housing Scheme—The Wedge Optical Pyrometer—A New Industrial Indirect Lighting Unit—Visit of the Brazilian Delegates to G.E.C. 197

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

Glasses for Protecting the Eyes from Injurious Radiations. By Dr. W. W. Coblentz and Mr. W. B. Emerson. Issued by the Bureau of Standards (Washington).

THE series of glasses studied is considered from the standpoint of avoiding excess of (1) ultraviolet, (2) visible, and (3) infra-red radiation. For the protection of the eyes from ultraviolet rays black, amber, green, greenish-yellow, and red glasses are recommended. Spectacles made of white crown glass afford some protection from the extreme ultraviolet rays, such as those developed in the quartz tube mercury vapour lamp, and arcs between iron, copper and carbon electrodes.

For shielding the eye from infra-red rays, deep black yellowish-green, sage-green, gold-plated and bluish-green glasses are serviceable. For working near furnaces of molten iron or glass, if considerable light is needed, a light bluish-green or sage-green glass is recommended for obstructing infra-red rays. For working molten quartz and for operating oxy-acetylene or electric welding apparatus, searchlights or other intense sources of light, it is important to wear the darkest glasses, either black, green, gold-plated or yellowish-green in order to avoid excess of all the varieties of radiation mentioned entering the eye. The paper is accompanied by diagrams showing the distribution transmission throughout the spectrum of a great variety of glasses of these types.

Transactions of the Illuminating Engineering Society in Japan.

RECENT issues of the *Transactions of the Illuminating Engineering Society* in Japan show that much interest is being taken in illuminating engineering. One feature deserving special mention is a series of photographs of lamps and lighting appliances developed in Japan from the earliest stages up to the present day. The line of development followed in passing from old illuminants to new ones will be followed with interest. As, however, the description of this collection is given exclusively in Japanese its contents are not readily accessible to European readers, and we hope that the Society will adopt the practice, which we have previously suggested, of including abstracts in English of their chief papers.

Pitman's Technical Bookshelf.

We have received No. 1 of the above publication issued by Sir Isaac Pitman and Sons, Ltd., which deals in a readable manner with new technical publications. An editorial note refers to the important part played by scientific and technical books in the movement for the fuller application of science to industry. We notice amongst new and forthcoming books, *Electric Motors and Control Systems* by Mr. A. T. Dover, *Gas and Oil Operation* by Mr. J. Okill, and the well-known *Whittaker's Electrical Engineer's Pocket Book.* There are also a number of works dealing with specific industries, some forming part of the "Common Commodities and Industries" series. The method of compilation of the new publication is novel and it should be useful to lecturers and others in search of technical books for their pupils.

Science and Industry in Canada, by Professor J. C. McLellan (Paper read before the Royal Society of Arts on March 4th, 1919).

In this paper Professor McLellan, who, after being educated in this country at Cambridge University, became Professor of Physics at Toronto University, and who until recently was one of the scientific advisers to the British Admiralty, presents an instructive survey of scientific and educational developments in Canada. Canada is rightly described as the land of opportunities. Its area is vast, and its population still relatively small, and it has great potential resources. The developments dealt with include mining, water power, agriculture, and many special industries, and a feature of the educational system is the series of special schools where the technicalities of these subjects can be studied. The various agricultural colleges, for example, are known thoughout the world. It is interesting to note that in Canada an exceptionally large number of students proceeds to the universities. In common with other countries Canada has recently taken special steps to encourage industrial research, adopting procedure similar to that in this country by appointing a sub-committee of the Privy Council to deal with the matter in 1916. The list of subjects mentioned as deserving attention covers a wide range and shows the opportunities for fruitful experiment

Industry in Parliament (Monthly Record of the British Commonwealth Union).

The June issue of this publication contains articles on a variety of topics of industrial importance. Capt. G. Bowyer, in a leading article on "Industry in Parliament," refers to the influence in the present Parliament of groups of members specially concerned with industrial problems, and there are notes on various topical matters, such as the creation of new industries, Nationalisation of Mines, National Finance and Increases in Wages. We observe an interesting note on conditions in Russia, where, it is stated, one pound of nails now costs 700 roubles (nominal value £70 !).

The British Journal of Ophthalmology (March, 1919).

The March issue of this journal contains a variety of notes of interest, including some suggestions for a new form of test-type for use in the examination of men in the Army. We notice that a Committee of the Council of British Ophthalmologists is undertaking an inquiry on the visual requirements desirable for men who are granted licences to drive motor-vehicles. A form of inquiry is published relating to men (a) who are blind in or have lost one eye, or (b) who habitually wear glasses.

Journal of the British Science Guild (July, 1919).

The *Journal of the British Science Guild* for July, 1919, contains an account of the proceedings at the 13th Annual Meeting, held on June 17th, including the addresses delivered by Major-General Seely, Lord Sydenham, and Sir Joseph Thomson. The Annual Report is again a summary of much useful work, reference being made to the reports of the committees on Education, the Metric System, etc.

Transactions of the Illuminating Engineering Society (U.S.A.).

The above issue contains several papers of exceptional interest bearing on camouflage problems. Lt. E. L. Warner deals with "The Science of Marine Camouflage," and with "Painting Battleships of Low Visibility." Lt. H. Van Buskirk likewise deals with the subject, while Mr. M. Luckiesh makes special reference to the problem of rendering aircraft difficult to distinguish. Some of the illustrations showing methods of painting ships so as to render their course difficult to ascertain are of special interest.

The
ILLUMINATING
ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by
LEON GASTER
THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

The Illuminating Engineering Society, 1909—1919.

The proceedings at the Annual Meeting of the Illuminating Engineering Society, which are summarised in this issue (pp. 205–214) mark the conclusion of the tenth session of the Society since its inception in 1909. Five years ago, immediately prior to the outbreak of war, we published a summary of the first five years' work of the Society up to that date, and a list of papers and discussions. We now take the opportunity to bring this information up to date by the inclusion of particulars for the subsequent years 1914-1919.

The history of the Society is thus sharply divided into two periods, the five years preceding the outbreak of war and the five years covering the war period. The record of papers and discussions during the latter period shows how completely the Society adapted itself to the war conditions. Many of the papers and discussions, notably those dealing with searchlights, the lighting of rifle ranges, economy in lighting, etc., had special relation to war conditions, and the two special committees formed to deal with the subjects, flares and self-luminous radio active materials, received a gratifying recognition of the value of their work from the Ministry of Munitions.

With the cessation of hostilities at the end of last year, the Society lost no time in reverting to its peace programme. The discussions during the present year on office, railway and stage lighting, were of great interest and in each case the variety of points raised in the discussion was such that it was decided to form new committees to deal with them in greater detail. The nucleus of the Committee on Railway Lighting has already been formed. It will have the benefit of the co-operation of engineers representing some of the leading railway companies, and will be free to add to its numbers as circumstances dictate. Similarly the Special Committee on Eyestrain in Cinema Theatres, formed by the Society in order to undertake an inquiry for the London County Council, has been completed. Both committees should do valuable work. Another committee which should present the Society with useful information is that formed to deal with Progress in Lamps and Lighting Appliances. It is suggested that this committee will be able to keep the Society informed of all the latest developments and to co-operate with it on such matters as the standardisation of dimensions, and the adoption of generally accepted methods of presenting information on the candlepower of lamps and lighting fittings.

These and the other committees in course of formation would in themselves provide the Society with ample work for the immediate future, apart from the usual papers and discussions at meetings. They afford a useful link between those engaged in the manufacture of lighting appliances and those concerned with their use and effect. In many other directions, especially through its representation on such bodies as the London "Safety First" Council, the Society will also continue to do good service.

The other point arising at the Annual Meeting to which we wish to call special attention, is the desirability of extending the membership of the Society, which has been fairly well maintained during the war, but should now continue the steady increase recorded previous to this period. From its inception the Society has been thrown open to both sexes, to those who are professionally connected with lighting and to those who are incidentally interested in one or other special aspects of illumination. It has now been decided to divide the membership into two classes (designated respectively "members" and "associates") representative of these two classes, a procedure which has already been adopted by the American and Japanese Illuminating Engineering Societies. Students will be eligible for the class of Associates, whose subscription will be limited to one guinea, but in the case of members the subscription, commencing from the 1st of October, 1919, will be two guineas. This step, which was foreshadowed in recent annual reports, has now become inevitable, in view of the increased expenditure of the Society since the outbreak of war and the prospective extension of its activities. The increased subscription compares favourably with that imposed by other bodies of similar standing.

In the reconstruction period on which we are now entering there should be many opportunities of exercising its influence in favour of better illumination. Looking back on the events of the past ten years we can see how materially public opinion has been modified in this direction through the Society's efforts, and it is of vital importance to the lighting industry that there should be available an impartial body to continue to exert this beneficent influence.

Street Lighting Reconstruction Problems.

In our last issue we commented upon the discussion at the Annual Meeting of the Illuminating Engineering Society on Street Lighting Reconstruction Problems, pointing out the desirability of uniform procedure throughout the greater London area, and the possibility of co-operation under some department, such as the Ministry of Transport, in supervising street lighting as a whole.*

We do not propose to repeat what was said on that occasion, but rather to deal with several of the more technical points that arose in the discussion. The characteristics of good street lighting are now fairly well defined. The fundamental point is the avoidance, so far as possible, of glare from unshaded mantles, arcs, or filaments within the ordinary range of vision, and of all excessive contrasts in brightness. Most people agree that while some light should be allowed to fall on the surfaces of buildings, the greater portion should be concentrated on the roadway and pavement, and that rays of light which escape upwards, *i.e.*, above the horizontal, are, comparatively speaking, wasted. Where less general agreement is expressed is in regard to the necessity of obtaining substantially uniform illumination between the public lamps. We agree that where the change in illumination occurs *gradually* there is much less objection to a variation than where sudden contrasts in brightness and darkness are made manifest. Avoidance of such contrasts as were experienced in London during the earlier stages of the war is vital. But, even assuming that the transition is gradual, it seems evident that it is better for the illumination to be uniformly distributed, if possible, than for such variations as 100 : 1 to occur. In a well-lighted street the difference is less serious, but in side streets where a minimum illumination of 0·025 foot-candles or less is not easy to obtain, it becomes more important, from motives of economy, to spread the light evenly. Moreover at such low illuminations the eye is much more conscious of variation. By mere casual inspection the street, as a whole, may appear fairly evenly lighted, despite a considerable diversity factor, but when one comes to identify an object at the spot where the lighting is weakest one immediately becomes conscious of the difference.

The provision of such uniform illumination is obviously a matter of special lantern and reflector-design. For that reason we would urge on manufacturers the development of suitable fittings of this kind for gas and electricity, of which we have only a few at present. As such design necessarily involves a high candlepower at angles slightly below the horizontal, the great importance of methods of diffusing the light to minimise glare is also evident. It may be argued with reason that where lamps are suspended at heights of 25 to 30 feet, a reflector to distribute the light is all that is needed. But at comparatively low mounting heights of 15—20 feet, we consider that some form of diffusing globe or lantern is necessary to get the best effect. The street lighting of the future will surely make much fuller use of such diffusing media, and we hope that the time is not far distant when experts generally will recognise that the fundamental principle of keeping all powerful unshaded lights out of the range of view is as desirable in street lighting as in the illumination of buildings.

---

* ILLUM. ENG., July, 1919, p. 178.

Co-operation between Public and Private Lighting.

One of the greatest obstacles to efficient street lighting at the present time is undoubtedly the feeling on the part of the authorities that economy must be exercised. Those who are familiar with lighting problems may recognise that a badly designed lighting installation is *ipso facto* uneconomical. But when the reconstitution of the street lighting may involve expenditure of thousands of pounds, it is only natural that there should be hesitation in incurring such expense, without good justification.

For this reason we should like to urge one other possibility in street lighting that has scarcely been touched as yet, namely, the harmonising of private outside lighting with public lighting on a uniform plan. During the war the measures for the screening of lights in shop-windows, and the elimination of glaring outside lights, were accepted with relief by the discerning public. In the coming winter, when restrictions may be partly relaxed and when powerful sources such as the gas-filled lamps will be more readily available, there is a great danger of a period of indiscriminate glare.

We should like to point out that in main thoroughfares the judicious regulation of private lighting might be of considerable assistance to street lighting, whereas, if left unchecked, it is likely to prove a nuisance owing to the distracting effect on the eyes of drivers and pedestrians. Shop-window lighting, if devised on rational concealed principles, is of considerable assistance, partly because it sheds a certain amount of diffused light on the pavement, but also because it relieves the general effect of dark surroundings which presents such a contrast with the bright public lamps. It is true that shop-window lighting may only be in evidence during shopping hours, but these are commonly hours of dense traffic. It is also likely that, when the coal situation has been improved, windows may eventually be maintained lighted after business hours, for the sake of advertisement, as was already becoming customary before the war.

More important than window-lighting, however, are the powerful lamps commonly installed outside shops and places of entertainment at a low level. If powerful unshaded lamps are used in this way they become a *menace* to traffic. If, on the other hand, the sources are of moderate power and are located in well designed diffusing lanterns, they may be a valuable aid to street lighting. We think, therefore, that municipalities owning electric plants and electric supply companies might well encourage such lighting by granting reasonable terms on condition that requirements as regards shading of lamps are complied with. The same applies to lamps outside theatres, cinema palaces, etc. If such concerns could be induced to adopt concealed lighting and flood lighting devices they would serve a useful purpose in relieving the general darkness.

We notice that the question of restoring the large electric signs on the Embankment has been actively discussed of late. Here, again, the extinction of the signs during the period of the war has been a relief. The use of such large disfiguring signs, which are detrimental to the appearance of the Embankment by night, should be prohibited. In the public interest the same criticism applies to the glaring flashing signs which, by distracting the attention of drivers or dazzling their eyes, are prejudicial to the safety of traffic. If such advertisements are allowed, it should surely be incumbent on their owners to employ methods which are not disfiguring but effective and artistic.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL MEETING.

(Proceedings at the Annual Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, June 24th, 1919.)

THE Annual Meeting of the Society was held at the House of the Royal Society of Arts, London, at 8 p.m., on Tuesday, June 24th, the chair being taken by Mr. W. C. CLINTON (Member of Council). Following the transaction of formal business a discussion on "Street Lighting Reconstruction Problems" took place.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of new applicants for membership as follows:—

Beach, E. A.	Electrical Contractor, Shawfield Street, Chelsea, London, S.W.3.
Hind, H. W.	Engineer, 13, Hind Street, Stockton-on-Tees.
Morgan, W. H. ..	Electrical Engineer, The General Electric Co., Ltd., 67, Queen Victoria Street, London, E.C.4.
Peers, F. W.	Electrical Engineer, 33, Cecil Road, Enfield, Middlesex.

The names of applicants presented at the previous meeting on May 30th were also read out, and these gentlemen were formally declared members of the Society.

The HON. SECRETARY then proceeded to read in abstract the Report of the Council for the session (see pp. 207–214). Reference was made to the large amount of work that had been done notwithstanding difficulties incidental to the war. With the cessation of hostilities, and the restoration of more normal conditions, the Society should make good progress and do much useful work. It would be observed that, as a result of discussions held during the past session, a number of new committees were in contemplation dealing with such subjects as office railway and stage lighting, and that a special joint committee was also being arranged to deal with the question of eyestrain in cinema theatres, and the best means of eliminating defects responsible. With the cessation of hostilities and the return to more normal conditions the prospects of the Society were bright, but it had now become necessary to carry into effect the arrangement, foreshadowed in previous reports but postponed during the war, for an increase in the subscription. The existing subscription was much less than that of any other body of similar standing, and in view of the great increase in expenses during the war, an increase had become inevitable.

The following resolution was then moved by Mr. J. G. CLARK, seconded by Mr. GEO. HERBERT, and declared carried unanimously:—

"That the Annual Report of the Council for the Session 1918-1919 be adopted and that a vote of thanks be moved to the Council and Officers of the Society for their services during the past year."

Mr. CLARK, in moving the resolution, remarked that to be able to present such a report would be regarded as very satisfactory even during normal times, but in view of the difficult period through which they had been passing it was greatly to the credit of the Society. He hoped that conditions would now become easier, lightening the task of the Council and Officers and enabling the Society to proceed with the various problems in the immense field for useful work that lay before them. Mr. HERBERT also referred in appreciatory terms to the efforts of the Council and Officers during the past year.

The HON. SECRETARY, in briefly expressing thanks on behalf of the Council, referred to the valuable assistance he had received from the Hon. Assistant Secretary, Mr. J. S. Dow.

The CHAIRMAN then moved the following resolution:—

"That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms during the past session, and record its appreciation of the encouragement and support which the Society has received."

Mr. C. E. GREENSLADE seconded, and the motion was carried with acclamation.

At this point in the proceedings the Chair was taken by the Deputy-Chairman of Council (Mr. F. W. GOODENOUGH), who called upon Mr. Leon Gaster to open the discussion on "**Street Lighting Reconstruction Problems.**"

Mr. L. GASTER, in his introductory address (see pp. 225-238), pointed out the chief conclusions to be drawn in regard to street lighting as a result of experience during the war, emphasising the importance of diffusing appliances in lessening glare and excessive contrasts in brightness, and the desirability of uniformity of practice as regards the principles of street lighting throughout the Greater London area.

Some proposals were made for the co-operation of bodies and authorities interested in order to obtain such uniform action, and it was also suggested that the matter might receive the attention of the new Ministry of Ways and Communications, working in co-operation with such bodies as the Illuminating Engineering Society, the Royal Automobile Club, and the London "Safety First" Council.

In the ensuing discussion the CHAIRMAN, Mr. J. G. CLARK, Mr. C. E. GREENSLADE, Mr. H. A. CARTER, Mr. J. N. STEPHENS, and Mr. W. C. CLINTON took part; and Mr. GASTER briefly replied to various points raised.

The CHAIRMAN announced that the next session would open in November, after which the meeting terminated.

NATIONAL PHYSICAL LABORATORY.

THE Lord President of the Council has appointed Professor Joseph Ernest Petavel, D.Sc., F.R.S., M.I.Mech.E., etc., to be Director of the National Physical Laboratory in succession to Sir Richard Glazebrook, C.B., F.R.S., who retires on reaching the age limit on September 18th next.

Professor Petavel is Professor of Engineering and Director of the Whitworth Laboratory in the University of Manchester. He is a member of the Advisory Committee for Aeronautics of the Air Ministry. He was educated at University College, London, and undertook scientific research at the Royal Institution and at the Davy Faraday Laboratory until 1898. He was elected John Harling Fellow of the Owens College, Manchester, in 1900, and was Scientific Manager of the Low Temperature Exhibit of the British Royal Commission for the St. Louis Exhibition, 1904.

REPORT OF THE COUNCIL FOR THE SESSION

(NOVEMBER 1918—JUNE 1919).

(Presented at the Annual Meeting of the Society held at 8 p.m. at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., on Tuesday, June 24th, 1919.)

THE Report of the Council for the Session 1918—1919 appears in happier circumstances than have prevailed on the occasion of the last four Annual Meetings. With the cessation of hostilities a resumption of more normal conditions in regard to lighting may be anticipated. The Society has already had the pleasure of welcoming back a considerable number of members who have been released from service with the colours, and since the date of the Armistice it has also received an encouraging influx of new members.

The Society has been fortunate in receiving the continued support of Mr. A. P. Trotter as President, and of Mr. F. W. Goodenough as Deputy Chairman of Council. In accordance with the arrangement entered into with the Institutions of Gas and Electrical Engineers, Mr. Samuel Glover and Mr. C. H. Wordingham, the acting Presidents of these bodies during the past session, kindly consented to become Vice-Presidents and Members of Council during their tenure of office. The Council are pleased to record that Sir Dugald Clerk, as President of the Institution of Gas Engineers during the coming session, has similarly consented to fill these positions.

Recognising the benefit of the opportunity of co-operation which this arrangement affords, the Council has determined to apply it to several other bodies dealing with subjects of common interest. Special interest attaches to the Council of British Ophthalmologists, which was recently formed by the co-operation of the leading ophthalmic surgeons in this country, in order to undertake specific inquiries relating to the functions of the eye. During the past session the Society has been privileged to receive the valued co-operation of the President of this body, Sir Anderson Critchett, as a Vice-President and Member of Council. The Ophthalmological Society has also nominated its President, Dr. J. B. Story, as a Member of Council of our Society. Cordial relations have also been established with several other societies, including the Royal Institute of British Architects, providing for co-operation on any question of common interest that may arise. The assistance of the Electrical Contractors Association, whose members are actively concerned in the equipment of lighting installations, has been likewise secured, and arrangements have been made by which the President of this Association will automatically become a Member of Council and Vice-President of the Illuminating Engineering Society. Mr. H. J. Cash, the acting President of the Association, kindly consented to fill these positions during the past session.

In view of the termination of hostilities and the prospect of fuller co-operation with other countries in matters of illumination, the Council desired to mark their appreciation of the valuable work done by the Illuminating Engineering Society in the United States during the war. They have accordingly nominated Mr. L. B. Marks, one of the founders and the first President of that Society, an Honorary Member, in recognition of the distinguished services which he has rendered as Chairman of the Committee on Lighting Legislation. They also take the opportunity of renewing the arrangement, which had fallen into abeyance during the war, by which the acting President of the American Society becomes a Vice-President of the Illuminating Engineering Society in this country during his tenure of office. Mr. S. E. Doane, who is already a member of our Society, and is known to many of our members, has accordingly been invited to accept this position. A similar invitation has been extended to Professor

Dr. Yamakawa, the first President of the newly-formed Japanese Illuminating Engineering Society, which appears to have started work under favourable auspices, and whose future progress will be watched with much interest

In the deaths of Sir William Crookes and Sir Boverton Redwood the Society has lost two distinguished Vice-Presidents, both of whom took a keen interest in the Society's work from its inception. The Council also record with regret the death of Dr. William J. Ettles, who was one of the first ophthalmic experts to interest themselves in the Society's investigations on the effect of light on the eye, and who frequently joined in discussions at the Society's meetings on the subject. Reference to the death of Sir William Crookes and Mr. Ettles has already been made in the official journal of the Society, and an appropriate notice of the recent death of Sir Boverton Redwood will appear in the next issue.

TENTH ANNIVERSARY OF THE SOCIETY.

The Tenth Anniversary Dinner of the Society, held at the Trocadero Restaurant on March 18th, was noteworthy both as the first gathering of the kind held since the outbreak of war and as marking the termination of ten years' work of the Society. There was a good attendance of members and friends, and practically all the Government Departments and kindred societies interested in the work of the Society were represented. The toast of the "Illuminating Engineering Society" was proposed by Mr. Thomas Goulden (Senior Vice-President of the Institution of Gas Engineers) and by Mr. C. H. Wordingham (President of the Institution of Electrical Engineers), both of whom alluded to the value of the impartial platform presented by the Society for the discussion of problems of common interest to gas and electrical engineers, and congratulated the Society on the progress it had made since its foundation ten years ago. Among others who responded to the toasts of "Kindred Societies" and "The Guests" were Sir George Beilby (Vice-President of the Royal Society), Col. J. Herbert Parsons (Council of British Ophthalmologists), Mr. A. A. Campbell Swinton (Chairman of Council of the Royal Society of Arts), Dr. T. M. Legge (H.M. Chief Medical Inspector of Factories), and Mr. H. C. Blain (Joint Hon. Secretary of the London "Safety First" Council), all of whom expressed their appreciation of the work which the Society had been doing in co-operation with other bodies, and wished it success in entering upon its second decade. Fuller particulars of this gathering will be found in the official organ of the Society.*

MEETINGS OF THE SOCIETY.

Five meetings of the Society, not including the Annual Meeting, have been held during the session.

At the opening meeting on December 19th a general discussion took place on "Progress in Photometry with special reference to War Problems," contributions being presented by the President and Mr. W. C. Clinton, summarising some features of the work undertaken for the Ministry of Munitions on the Candle-power of Flares and Parachute Lights, and the Brightness of Radio-active Self-luminous Materials, by two committees of the Society. This information was given by the permission of the Ministry, several representatives of which were present and joined in the discussion.

On January 21st a Paper on "Modern Practice in Office Lighting" was read by Mr. A. Wise, the subject being selected as a timely one in view of the probability of many installations undergoing revision in the near future. A number of useful points were raised in the discussion.

The next meeting, on February 25th, was devoted to a Paper by Mr. A. Cunnington, entitled "Some Notes on Railway Lighting and its Maintenance," which carried to a further stage the discussion of this subject commenced by the Society about seven years ago. A number of railway engineers attended and took part in the discussion, much interest being shown in the tentative suggestions put forward for standard values of illumination on railway platforms, and in goods yards, goods sheds, etc.

On April 8th an interesting Paper on "The Art of Stage Lighting" was read by Mr. J. B. Fagan, of the Royal Court

---

* ILLUM. ENG., April, 1919.

Theatre. On this subject it seemed desirable to obtain the assistance of outside experts conversant with theatrical matters, and the meeting was accordingly arranged with the co-operation of the Critics' Circle of the Institute of Journalists, a number of whom, including the Chairman, joined in the discussion. The Society had also the opportunity of hearing the views of various gentlemen associated with the theatrical profession.

At the last meeting previous to the Annual Meeting, on May 30th, a discussion on "The Gas-filled Lamp and its Effect on Illuminating Engineering" was opened by Mr. F. W. Willcox. In view of the interest of this subject to electrical contractors and others concerned with the equipment and maintenance of lighting installations, a general invitation to be present was extended to the members of the Electrical Contractors Association, the Association of Supervising Electricians and the Association of Engineers in Charge. The subject was considered specially timely in view of the large number of installations which will now require modification or redesign, and for which the gas-filled lamp would have many useful applications.

Naturally it was only possible to present a general review of the subject, but it is anticipated that other opportunities will be afforded at forthcoming meetings for the discussion of special applications of the gas-filled lamp.

The attendance at meetings during the past session was satisfactory, a gratifying feature being the presence of a considerable number of students at technical institutions, by whom a keen interest in matters of illumination is being shown.

FORMATION OF NEW COMMITTEES.

New Committees on Office Lighting, Railway Lighting, and Stage Lighting.—The various discussions were also useful in revealing a number of points on which fuller information is required, and it is proposed to deal with these through the medium of three new small committees. Thus a committee on "Office Lighting" is being formed to deal with some of the points arising from the discussion of Mr. A. Wise's paper, and to present some general recommendations on this subject to serve as a guide to the general public. Similarly it is proposed to form a small joint committee, on which members of the Society and engineers associated with the chief railway companies will serve, with a view to drafting some useful general conclusions on railway lighting; and another committee, representative of the Society and gentlemen connected with the theatrical profession to inquire further into the subject of stage lighting.

Committee on Lighting Conditions and Eye-strain in Cinema Theatres.—Another investigation, involving co-operation between lighting experts and ophthalmologists, is the study of lighting conditions and possible sources of eye-strain in cinema halls, a matter which was discussed in a Paper read by Dr. James Kerr before the Society in February, 1917. Representatives of the Cinema Commission of Inquiry—a body which was then conducting a general inquiry into conditions in cinema theatres, joined in the discussion of Dr. Kerr's Paper, and conveyed an invitation from the Commission to co-operate in lighting matters. Evidence was subsequently given before the Commission by the Hon. Secretary of this Society (Mr. L. Gaster), and it was resolved that the Society should form a small committee to carry out an investigation of the lighting of cinema theatres in greater detail. The matter of the provision of artificial lighting in cinemas, apart from that necessary to illuminate the screen, has since been the subject of further official inquiry, and the Society has been requested to advise on the strain on the eyes caused by the proximity of seats to the screen and other circumstances, and the best means of lessening the ill effects referred to. The problem obviously demands the experience of various experts, including ophthalmologists, and it has been decided to deal with the matter through a joint committee to be appointed by the Society. Among the bodies which it is proposed should be represented are: The Illuminating Engineering Society, the Council of British Ophthalmologists, the Physiological Society, the Cinema Commission of Inquiry and Cinema Producers. It is hoped that the results of this investigation will serve as a guide not merely to desirable practice in London, but to the conditions throughout the country.

Committees on Flares and Radioactive Self-Luminous Materials.—The two Committees carrying out investigations for the Ministry of Munitions on the Illuminating Power of Flares, Parachute Lights, etc., and on the Brightness of certain Radioactive Luminous Materials, presented several reports of their inquiries to the Ministry, who acknowledged these services in very appreciatory terms. Permission was accorded for a general account of the photometric methods pursued to be given at the opening meeting of the Society, referred to above, and for the apparatus designed to be exhibited. These researches afforded an interesting example of the application of knowledge acquired in time of peace to war problems, and it is also hoped that the experience gained during the war will prove useful in other photometric investigations in the future.

CO-OPERATION WITH OTHER BODIES.

British Scientific Products Exhibition.—The general interest which has been aroused during the war in the development of research and the application of science to industry was illustrated by the successful inauguration of the British Scientific Products Exhibition last year. By the courtesy of the Ministry of Munitions the special photometers for testing the illuminating power of flares were exhibited at this Exhibition. The Society was represented on the sub-committee to which matters of illumination were referred, and progress in illuminating engineering was summarised in a lecture delivered by Mr. Gaster at the Exhibition and in a descriptive article published in the catalogue. This Exhibition will be repeated on a larger scale during July and August in the present year, and the Society has again been invited to cooperate.

Research in Illuminating Engineering.—The present moment is a favourable one for the initiation of research in the field of illuminating engineering, and in the future there should be many opportunities for embarking on such inquiries with the co-operation of kindred societies and associations. The Committee on Illuminating Engineering, formed under the Department of Scientific and Industrial Research in 1917, affords a valuable medium for the prosecution of research demanding such concerted action, and especially for such inquiries as are too extensive to be undertaken by an individual. The Committee are also prepared to consider any investigations which individual members of the Society may desire to carry out with their help, and the Hon. Secretary of the Society will be glad to convey any such applications.

Illuminating Glassware.—One of the subjects which has already received the attention of this Committee is the question of illuminating glassware. It will be recalled that this matter also formed the subject of a joint conference attended by prominent members of the Illuminating Engineering Society and the Society of Glass Technology, and representatives of other bodies and departments interested in illuminating glassware, immediately before the last annual meeting. The conditions affecting the manufacture of illuminating glassware in this country were discussed in some detail, and the following resolution was proposed by Mr. A. P. Trotter (President of the Illuminating Engineering Society), seconded by Mr. W. F. J. Wood (President of the Society of Glass Technology), and carried unanimously:—

"That this Conference is of opinion that the shortage of illuminating glassware is growing to such an extent that it is essential for the Government to give every facility for the manufacture in this country of such glassware, and that lamp chimneys, bulbs, globes, etc., are considered to be of the nature of a semi-key industry."

With a view to ascertaining the position at the moment and in the immediate future, it was agreed that the Illuminating Engineering Society should endeavour to obtain the necessary statistical data.

The Resolution was duly conveyed to the authorities concerned. While changing conditions led to the inquiry not being pursued in detail at that time, it would appear to be a profitable subject for investigation now, in view of the future of the illuminating glass industry in this country.

Illumination of Optical Test Charts.—From its inception the Society has always been anxious to obtain the co-operation of the medical profession in studying the effects of light on the eye, and it has accordingly established friendly relations with the various societies concerned with ophthalmology. Amongst these the recently formed Council of British Ophthalmologists is in a very favourable position to deal authoritatively with such special inquiries, and an opportunity presented itself for co-operation by this Society in connection with the committee appointed by the Council to determine standard conditions of illumination for optical test charts used in the examination of candidates for the public service. A report was issued by this committee early in the present year. The inquiry into eye-strain in cinema theatres, referred to above, will afford another opportunity for useful co-operation with the Council and other bodies interested in the hygiene of vision.

National Illumination Commission.—An event of interest, anticipating the resumption of international discussion of problems in illumination, has been the resumption of meetings of the National Illumination Commission. On May 29th Mr. A. P. Trotter, representing the Illuminating Engineering Society, was appointed Chairman in place of Mr. W. Duddell, and Mr. C. C. Paterson has been nominated to fill the vacancy for a representative of this Society on the National Illumination Commission. Mr. L. Gaster is one of the two representatives on the Executive Council of the International Illumination Commission.

Representation on the Conjoint Board of Scientific Societies.—At a meeting of the Conjoint Board of Scientific Societies, held on June 11th, the Illuminating Engineering Society was nominated one of the constituent societies of this body, and has been requested to appoint a representative. This step will doubtless lead to new opportunities for co-operation in matters of general interest, and is a fitting recognition of the essential scientific nature of the work undertaken by the Illuminating Engineering Society.

Economy in Lighting.—It will be recalled that at the last Annual Meeting a discussion took place on the Lighting, Heating and Power Order, 1918, and a series of recommendations on economy in lighting, intended as a general guide to consumers regarding the best methods of meeting the requirements of the Order, were presented. Subsequently the Household Lighting and Power Order, embodying a joint scheme of rationing in coal, gas or electricity, was introduced. Here again useful advice to consumers was offered in the form of an article on "The Lighting Ration in Practice," published in the official organ. During the summer months of 1918 certain London boroughs proposed a further diminution in street-lighting during the summer months, as an experimental measure of economy. The proposal was sanctioned by the authorities subject to the reduction being spread evenly over both main and side streets so as to be without prejudice to a uniform lighting effect and also to the measure being supervised should it be found that the reduced lighting led to increases in crime or danger to pedestrians or traffic, or impeded the supervision of the streets. The matter came before a meeting of the Lighting Sub-Committee of the London "Safety First" Council at which these and other points were discussed.

Street-lighting Reconstruction Problems.—With the cessation of hostilities the authorities sanctioned the removal of restrictions in regard to the screening of public lamps, subject to the continued diminution of 50 per cent. of lighting in the interests of fuel-saving. It is hoped that after the prospective signing of peace restrictions will be completely withdrawn. Meantime "reconstruction problems" in street-lighting have been discussed at various meetings of the Lighting Sub-Committee of the London "Safety First" Council, on which the Society is represented. Resolutions passed have dealt chiefly with such matters as the preferential restoration of street-lighting in streets which form routes for trams and omnibuses, the provision of adequate illumination at the starting and stopping places of such vehicles, and other matters of importance from the traffic standpoint. Opinions have also been expressed in favour of the use of suitable diffusing devices with powerful lamps, and the avoidance of excessive contrasts in brightness, such as are liable to prove distracting to the eyes of drivers and pedestrians and a source of danger to traffic. Two points, the importance of diffusion of light from outside lamps in order to avoid glare, and the desirability of concerted action in the various London boroughs so as to ensure uniform procedure in regard to street-lighting (and especially elimination of undesirable contrasts in brightness in passing from one street to another), stand out in special prominence from such discussions. The whole question of the future of street-lighting is of great importance and it has been arranged to hold a discussion on the subject at the Annual Meeting.

Industrial Lighting.—In their previous reports during the last few years the Council have commented upon the growth of interest in factory lighting, as a result of the exceptional demands made on the factories of the country since the outbreak of war. It has been remarked, for example, that the reports issued by the Health of Munition Workers' Committee have consistently urged the importance of adequate lighting in the interests of health, safety and efficiency of work, thus endorsing the conclusions of the Departmental Committee on Lighting in Factories and Workshops issued in 1915. A further opportunity for the study of the various effects of lighting in relation to fatigue is provided in the Research Board, set up by the Department of Scientific and Industrial Research and the Medical Research Committee, on Industrial Fatigue.

Another step of considerable importance has been the formation of the British Industrial "Safety First" Association, a development of the London "Safety First" Council following the conference held at the Mansion House on June 12th, 1918, and the subsequent council meeting on October 31st. By the creation of this new body the "safety first" campaign, which has already been applied so successfully to the diminution of street accidents in London will be extended to industrial operations. The Illuminating Engineering Society is appropriately represented on this new body, whose influence will doubtless be strongly exerted in favour of adequate industrial lighting in the interests of safety. Another aspect of industrial lighting, its relation to improved output and quality of work, has been strongly emphasised by events during the war. The study of performances of some of these new large plants, working on uniform products, should afford useful evidence of the effect of good illumination on production.

In the United States industrial lighting has likewise received much attention since the outbreak of war, a feature being the continual increase in the number of States that have adopted legislative "codes" specifying requirements for the lighting of factories, five States—Pennsylvania, New Jersey, Wisconsin, New York and Oregon—having already adopted this procedure, while others have codes in preparation. It is to be hoped that in the near future definite general requirements of adequate factory lighting will be introduced into the British Factory Act, and that this country will regain the lead that it formerly held in these matters.

ADDITIONAL SUPPORT REQUIRED.

The enumeration of these many fields of activity of the Society leads to the mention of one matter which has long been considered unsatisfactory, namely, the present financial support which the Society receives Both in respect of revenue and as regards voluntary assistance, the Society stands in a much less favourable position than the corresponding body in the United States, whose income is approximately fifteen times as great and whose membership is roughly three times as great as that of this Society. It is evident also that even the newly-formed Japanese Society starts operations on a much more satisfactory financial footing than that enjoyed by our Society after ten years of existence.

In previous Annual Reports reference has frequently been made to this matter, and it has been pointed out that it would probably be necessary to increase the present moderate subscription of the Society at the first opportunity. Although the advisability of this step was recognised even before the war, the Council were reluctant to make the change during a period of general sacrifice. But with the conclusion of hostilities and the termination of ten years' work of the Society, it is now felt that an advance in subscription is imperative. There is now no other Society of standing whose subscription is as low as that hitherto adopted by the Illuminating Engineering Society, and even with the suggested increase to two guineas, the subscription will fall below that of most professional bodies. During the war the expenditure of the Society in many directions has increased considerably owing to the increased cost of paper, printing and other items, and it would have been quite impossible to have retained the existing subscription so long, but for the fact that the Society has benefited by the arrangement providing for THE ILLUMINATING ENGINEER to act as the official organ, and by not being called upon to pay many customary expenses, such as secretary's salary, etc.

In accordance with the powers conferred by the Constitutions, the Council has accordingly decided in the interests of the Society to alter the Annual Subscription of ordinary members from One Guinea to Two Guineas, the increase to commence with subscriptions falling due in October, 1919. The subscription for Life Members shall be not less than Fifteen Guineas.

It is further proposed that persons who are over the age of 16 years, and are students at technical colleges, or persons over the age of 21 years, who, while not technically connected with the lighting industry, sympathise with the aims and objects of the Society and whose co-operation would be beneficial thereto, shall be eligible as "Associates."

The subscription for Associates shall be not less than one guinea per annum. Associates will have the privilege of attending the meetings of the Society and receiving the official organ, but shall not have voting power nor be eligible for office.

Students who are continuing their education and who propose to become professionally connected with the lighting industry shall have the option of being transferred to the class of members after attaining the age of 21 years; but shall not remain in the class of Associates after attaining the age of 25 years. In the event of their not being so connected they shall be free to continue in the class of Associates.

Existing members who are professionally associated with the lighting industry shall continue their membership at the increased subscription of two guineas per annum; but existing members who are not so professionally connected shall have the option of applying to be transferred to the class of Associates at a subscription of not less than one guinea.

The determination of the class for which an applicant is eligible shall rest with the Council.

FUTURE PROSPECTS OF THE SOCIETY.

In view of the small financial support received, and the fact that it has relied hitherto exclusively on voluntary assistance, the progress of the Society and the extension of its influence during the last ten years affords great hope for the future. In the circumstances, the maintenance of work during the war period has been very satisfactory, although, needless to say, it has imposed considerable difficulties on the Officers. With the cessation of hostilities and the release of many members of the Society from the forces or other special war-work, this work should be capable of considerable extension. From the foregoing it will be noted that the Council has in prospect the formation of a number of new Committees, and by this and other means it is hoped to provide opportunities for a larger proportion of members to assist actively in the Society's work. It will be recalled that previous to the war efforts were made to develop a larger membership at the chief provincial centres, leading ultimately to the formation of local centres. An initial step in this direction would be the promotion, at the chief provincial centres, of special meetings devoted to topics of local interest (such as the lighting of shipyards, engineering works, textile mills, etc.). During the war this work was inevitably left in abeyance, but it is now proposed to continue this development, and also to seek outlets for arousing interest in the Society's work in the various Colonies and Dominions.

Finally, with a view to the future, it appears desirable to do more to interest students and the younger members of the Society. It is thought that the present needs might be met by the institution of courses of lectures on illuminating at some of the chief colleges and institutions, thus carrying out more fully the principle adopted experimentally some years before the war, and that ultimately regular meetings of a students' section might be arranged. There is ample evidence of continued growth of interest in illumination, and provided the necessary financial support is forthcoming to facilitate these extensions of operations the Society should now enter upon a period of great usefulness and prosperity.

A. P. Trotter, *President.*
L. Gaster, *Hon. Secretary.*

Obituary.

PROFESSOR A. G. VERNON HARCOURT,

Born December 24th, 1834—Died August 23rd, 1919.

We record with deep regret the death of Professor A. G. Vernon Harcourt, who passed away in his 85th year, on August 23rd.

During his long and active life Professor Harcourt filled many responsible positions. He was intimately associated with the Chemical Society, and served as its secretary for eight years. He became a Fellow of the Royal Society in 1868 and served on its Council, and he took a deep interest in the work of the British Association. He early applied his knowledge of chemistry to the purification and testing of coal gas, being appointed one of the Gas Referees, whose duty it was to specify the mode of testing gas in London and fix the degree of impurity allowed.

To illuminating engineers he is, however, best known for his important work on standards of light, in recognition of which he was made an Honorary Member of the Illuminating Engineering Society. When the search for a satisfactory standard to replace the so-called "standard candle" was undertaken, Professor Harcourt's experiments on the use of pentane, originally in the form of the one candlepower lamp, naturally received attention. Ultimately this was replaced by the well-known 10 candlepower Pentane standard, which ranks among the first adequate standards of light evolved, and has been widely adopted not only in this but in other countries.

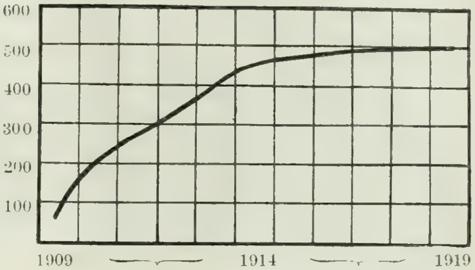
Professor Harcourt took a keen interest in the work of the Illuminating Engineering Society. He joined in one of the very first discussions, instituted in 1909, on "The Measurement of Light and Illumination," and in spite of advancing years he was present at the Annual Dinner of the Society held in 1910. On the occasion of the tenth anniversary of the official organ of the Society, in January, 1918, he sent us a cordial congratulatory message.

He had the simplicity of manner and kindly disposition which one has learned to associate with all great men of science, and was always willing to aid with advice and information those with whom he came in contact.

THE WORK OF THE ILLUMINATING ENGINEERING SOCIETY.

The Illuminating Engineering Society was formed in London in 1909. Its membership, prior to the Annual Meeting this year, attained nearly 500, and the adjacent diagram shows the steady increase in membership, which was maintained throughout the period of the war.

But now the time has come when the Society requires a greatly enlarged membership in order to carry out the important work before it and extend its activities.



Growth of Membership of The Illuminating Engineering Society, 1909—1919.

In the following pages we are summarising the work so far done. We think that those who read the account will agree that this is a movement which deserves the fullest recognition.

WHAT THE SOCIETY HAS DONE.

The Illuminating Engineering Society has provided **a platform for the impartial discussion of illumination,** a friendly meeting place for architects, medical men and engineers connected with all methods of lighting. It is most important to the lighting industry that **this atmosphere of " fair play " should be maintained.**

During its ten years of existence the Society has held 64 meetings. The **total attendance,** obtained by adding up the number of people present at each meeting, approaches 1,300, approximately 60 per cent. of whom were visitors specially interested in the various subjects discussed. Upwards of 600 contributions have been made to the discussions.

The proceedings have been regularly reported in the official organ, THE ILLUMINATING ENGINEER, and have received a unique and widespread attention in the technical and daily press. **The Journal is habitually quoted by over 100 periodicals and daily papers,** and the movement is thus **brought to the notice of millions of people every year.**

By the efforts of the Society, articles dealing with various aspects of illumination have also appeared in many special journals read in circles which it was desired to influence in favour of good illumination.

Besides appealing to the general public, **the movement receives support from many distinguished engineers and scientific men.** Its **first President** was the late **Professor Silvanus P. Thompson, D.Sc., F.R.S.,** whose successor in office was **Sir William Bennett, K.C.V.O.,** F.R.C.S., Surgeon to H.M. the King, and the President (for the current year) is **Mr. A. P. Trotter,** who has been responsible for much early pioneering work in photometry and illumination.

The movement enlists the sympathy of those associated with pure and applied science engineering and architecture. At the Annual Dinners of the Society, for example, the Society has been honoured by the presence of, among others, the following distinguished guests :—**The Presidents of the Royal Society, the Institutions of Gas and Electrical Engineers, and The Ophthalmological Society, the Director of The National Physical Laboratory, The Secretary of the Department for Scientific and Industrial Research, The Chairman of the Royal Society of Arts, The President of the Institution of County and Municipal Engineers, The President of the Electrical Contractors Association ;** whilst among other bodies and Government Departments represented may be mentioned the **Council of British Ophthalmologists, the Ministry of Munitions, the British Science Guild, the Home Office (Factory Dept.), the Royal Institute of British Architects, the London "Safety First" Council,** etc.

With many of these bodies the Society maintains intimate relations, and in order to facilitate co-operation on subjects of mutual interest an arrangement has been made by which the acting Presidents in many cases become members of Council of the Illuminating Engineering Society (see page 220). During the present year the Society was also added to the list of constituent bodies of the **Conjoint Board of Scientific Societies.**

On the occasion of the **Tenth Anniversary** of the official organ of the Society (THE ILLUMINATING ENGINEER) a series of **messages from sixty prominent scientific men,** representatives of the leading firms associated with the manufacture of lamps and lighting appliances and companies engaged in the supply of gas and electricity, besides experts interested in the hygienic and other special aspects of illumination were received, all expressing keen sympathy and interest in the aims and objects of the Society.* This illustrates the wide circle to whom the movement for better illumination appeals.

The Society interests all classes. It brings the manufacturer of lighting appliances in contact with the actual user of them. For example, when discussing Library Lighting a **Joint Meeting with the Library Association** was arranged : subsequently the proceedings were reprinted by the Library Association and distributed among all its members. Similarly, when dealing with **School Lighting** the co-operation of medical and educational authorities was secured. Subsequently **Joint Committees on School and Library Lighting** were formed. These Committees have already issued interim reports on these subjects,† which have received attention in most influential quarters. Already, through the work of our Society the standard of lighting in many schools through the country is being raised.

The Illuminating Engineering Society was also instrumental in forming the **Joint Committee on the Standard Specification for Street Lighting,** on which, for the first time, delegates from the Institutions of Gas, Electrical, and Municipal and County Engineers worked together. Wishing to provide an opportunity for open discussion of this difficult subject the Committee determined to avail themselves of the impartial platform of the Illuminating Engineering Society. The paper read by Mr. A. P. Trotter on the subject attracted notice far and wide throughout the country and has already done much to raise the status of street lighting.‡

Since the illuminating engineering movement was started a continually increasing amount of attention has been paid to illumination in the reports of H.M. Chief Inspector of Factories. This has culminated in the **appointment by the Home Secretary of a Departmental Committee to inquire into Industrial Illumination,** which issued a most valuable and comprehensive interim report in 1915,§ recommending that there should be statutory provision requiring : "(A) Adequate and suitable lighting in general terms in every part of a factory or workshop, and (B) giving power to the Secretary of State to make Orders defining adequate and suitable illumination for factories or workshops or for any parts thereof or for any processes carried on therein." The confirmation of this recommendation was unavoidably postponed during the war, but it is expected to be carried into effect shortly. Meantime in five of the United States (New York, New Jersey, Pennsylvania, Wisconsin and Oregon) codes of industrial lighting are in actual operation, and it is anticipated that the matter will be the subject of international consideration in the near future.

An important element in the Society's work has been its encouragement of **good illumination in the interests of safety** which is aided by the representation of the Society on the London "Safety First" Council, and on the kindred body established to deal with industry, The British Industrial "Safety First" Association. A pamphlet emphasing the value of good lighting in the interests of safety is in course of preparation.

---

* ILLUM ENG., Jan., 1918.

† ILLUM. ENG., July, 1913, and July, 1914.

‡ ILLUM. ENG., May and June, 1913.

§ ILLUM. ENG., Sept., 1915.

On these committees the co-operation of other bodies interested will be obtained. Another subject where the facilities for co-operation already established with the Council of British Ophthalmologists and other bodies concerned with the study of vision will be valuable is the **Effect of Light on the Eye.** The Society was represented on the committee formed under the auspices of the above named Council to study the illumination of optical test-charts, which has already reported and will receive its assistance in dealing with the question of Eye-strain in Cinemas.

During the war the Society, at the request of the **Ministry of Munitions,** formed two committees to undertake researches on **radioactive self-luminous materials** having special war applications, and on the **illuminating power of flares, parachute lights,** etc.* Both committees conducted exhaustive experiments and issued reports which were much appreciated, and received the cordial thanks of the Ministry for their services. In connection with **Economy in Lighting** a series of recommendations to consumers was issued (with the concurrence of the Board of Trade) showing how the requirements of the Household Fuel and Lighting Order could be most readily complied with.† The Society and its members have also assisted by advice and experiment on many other technical matters during the war, and discussions at meetings on such subjects as **Searchlights,** the **Lighting of Rifle Ranges,** etc., have proved most helpful.

With the termination of hostilities and the signing of peace the time has come for the Society to extend its investigations on topics of general interest, and, as a result of discussions during the last session committees to inquire into the following subjects of:—**Office Lighting, Stage Lighting** and **Railway Lighting** are being formed. In addition, at the request of the London County Council a Joint Committee has been formed to deal with the subject of **Eyestrain in Cinema Theatres,** in relation to lighting conditions, and the best method of eliminating conditions responsible therefor. (See page 219).

It is hoped shortly to complete the arrangements contemplated at the outbreak of war to extend the membership of the Society throughout the provinces, with the intention that ultimately local branches may be formed. Meanwhile a re-arrangement of the conditions of membership has been decided upon which, it is hoped, will be of assistance in enabling students and outside experts not professionally connected with lighting, to take a fuller part in the Society's proceedings. (See page 213.)

From the commencement of the Society's work it has aimed at an international connection in order that members may be kept informed of progress in illumination in various parts of the world. In this connection the information afforded by the corresponding members of the Society in all the chief cities of Europe and in the United States has been of great value. During the war international congresses have naturally been in abeyance, but in the future there will be opportunities of thus extending the Society's influence. Among such congresses at which the Society was represented in the past may be mentioned :

The International Congress on Industrial Hygiene (Brussels, 1910).
The International Hygienic Congress (Dresden, 1911).
The International Electrical Congress (Turin, 1911).
The First International Congress for the Prevention of Industrial Accidents (Milan, 1912).
The Fourth International Congress on School Hygiene (Buffalo, 1913).
The Annual Congress of the Royal Institute of Public Health (Paris, 1913).

An Illuminating Engineering Society with similar aims to the corresponding bodies in this country and the United States has recently been formed in Japan.

During the present year the National Illumination Committee of Great Britain, the branch in this country of the International Commission on Illumination, formed in 1913, has resumed its work and doubtless the international treatment of scientific questions relating to illuminating engineering will also be taken up in due course.

---

* ILLUM. ENG., Nov. and Dec., 1918.

† ILLUM. ENG., May and July, 1918.

Illuminating Engineering Society

(Founded in London, 1909.)

JOINT COMMITTEES (1919).

National Illumination Committee of Great Britain.

Mr. A. P. Trotter (Chairman), Mr. L. Gaster, Mr. F. W. Goodenough, Dr. J. Kerr, Mr. C. C. Paterson, representing *The Illuminating Engineering Society.*

Mr. F. Bailey, Mr. W. C. Clinton, Mr. K. Edgcumbe, Mr. Haydn T. Harrison (Hon. Secretary), Prof. J. T. McGregor Morris, representing *The Institution of Electrical Engineers.*

Mr. J. Abady, Mr. J. Bond, Prof. H. G. Colman, Mr. W. J. A. Butterfield, Mr. R. Watson, representing *The Institution of Gas Engineers.*

Sir Richard Glazebrook, C.B., Mr. J. W. T. Walsh, representing *The National Physical Laboratory.*

Representatives of the Committee on the Executive Committee of the International Commission on Illumination :—Dr. Harold G. Colman and Mr. Leon Gaster.

Joint Committee on the Standard Specification for Street Lighting.

Mr. W. H. Patchell (Chairman), Mr. F. Bailey, Prof. J. T. McGregor Morris, Mr. K. Edgcumbe, Mr. S. L. Pearce, Mr S. Z. de Ferranti, Mr. H. F. Proctor, Mr. Haydn T. Harrison, representing *The Institution of Electrical Engineers.*

Mr. W. Doig Gibb (resigned December, 1911), Mr. S.Y. Shoubridge, Mr. R. Watson, representing *The Institution of Gas Engineers.*

Mr. E. J. Elford, Mr. T. W. A. Hayward, Mr. G. F. Carter, Mr. E. B. B. Newton, Mr. N. Scorgie, representing *The Institution of Municipal and County Engineers.*

Mr. L. Gaster, Mr. J. W. Ife, Mr. F. W. Goodenough, Mr. A. H. Seabrook (resigned November, 1911), Mr. A. P. Trotter, representing *The Illuminating Engineering Society* ; Mr. J. W. Bradley (*co-opted*).

Special Joint War Committee on Testing the Illuminating Power of Flares, Star Shells, etc.

Mr. A. P. Trotter (Chairman), Mr. L. Gaster (Secretary), Mr. J. G. Clark, Mr. W. C. Clinton, Mr. J. S. Dow, Prof. J. T. McGregor Morris, representing *The Illuminating Engineering Society.*

Mr. A. Blok, representing *The Ministry of Munitions* (O.M.G.).

Mr. Maurice Blood, representing *D.I.S.A.A.*, *Royal Arsenal, Woolwich.*

Capt. G. H. Wicks, representing *The Chemical Warfare Dept., Ministry of Munitions.*

Special Joint War Committee on Testing the Brightness of Radio-Active Self-Luminous Materials.

Mr. L. Gaster (Chairman), Mr. W. C. Clinton, Mr. J. S. Dow (Secretary), representing *The Illuminating Engineering Society.*

Mr. A. Blok, representing *Ministry of Munitions* (O.M.G.).

Joint Committee on School Lighting.*

Asst. Prof. W. C. Clinton, Mr. J. Darch, Mr. J. S. Dow, Mr. L. Gaster (Secretary), Mr. F. W. Goodenough, Dr. H. R. B. Hickman, Dr. J. Kerr (Chairman), Mr. W. R. Rawlings, Mr. T. E. Ritchie, Mr. A. Stokes, Mr. S. E. Thornton, Mr. P. J. Waldram, representing *The Illuminating Engineering Society.*

Dr. R. S. Clay, representing the *Association of Technical Institutions.*

Dr. J. H. Vincent, representing the *Association of Teachers in Technical Institutions.*

Mr. E. S. Mortimer, representing the *London Teachers' Association.*

Dr. E. H. Nash, representing the *Medical Officers of Schools Association.*

Mr. N. Bishop Harman.

Joint Committee on Library Lighting.*

Dr. W. M. Bayliss, Mr. J. G. Clark, Mr. J. S. Dow, Mr. J. Eck, Mr. L. Gaster (Secretary), Mr. S. Hamp, Mr. Haydn T. Harrison, Mr. Chas. W. Hastings, Mr. B. H. Jenkinson, Mr. V. H. Mackinney, Mr. N. W. Prangnell and Mr. A. P. Trotter (Chairman), representing *The Illuminating Engineering Society.*

Mr. H. Bond, Mr. J. Duff Brown, Mr. B. Carter, Mr. Hopwood, Mr. H. Jones, Mr. R. Peddie, and Mr. H. R. Tedder, representing the *Library Association.*

Joint Committee of Enquiry on Eye-Strain in Cinema Theatres and its Prevention.*

Mr. A. Blok, Asst.-Prof. W. C. Clinton, Mr. J. S. Dow, Mr. L. Gaster (Secretary), Mr. F. W. Goodenough Mr. Haydn T. Harrison, Prof. J. T. McGregor Morris, representing *The Illuminating Engineering Society.*

Col. J. H. Parsons, C.B.E. (Chairman), Mr. Stephen Mayou, Mr. W. H. McMullen, O.B.E., and Mr. Bernard Gridland, representing *The Council of British Ophthalmologists.*

Prof. W. M. Bayliss, Dr. W. MacDougall, Prof. C. S. Sherrington, Prof. C. Spearman, representing *The Physiological Society.*

Mr. E. Ridley (*Inspection Dept., London Fire Brigade, L.C.C.*), Dr. James Kerr (*Medical Research Officer, Public Health Dept., L.C.C.*), (Deputy Chairman), Dr. C. W. Kimmins (*Chief Inspector, Education Officer's Dept., L.C.C.*).

Mr. F. G. Goodwin, Mr. A. E. Newbould, Mr. J. W. Barber, representing the *Cinema Industry.*

Joint Committee on Railway Lighting.*

Lieut.-Col. F. A. Cortez Leigh (London and North Western Railway), Chairman, Mr. J. S. Dow, Mr. L. Gaster, Mr. F. W. Goodenough, Mr. A. Stokes, Mr. A. Cunnington (London and South Western Railway), Secretary, representing *The Illuminating Engineering Society.*

Mr. A. R. Cooper (Underground Railways), Mr. Wood (North British Railway), Mr. Roger T. Smith (Great Western Railway), representing *The Association of Railway Electrical and Telegraph Engineers.*

Committee on Progress in Lamps and Lighting Appliances.*

Electric :—

Mr. F. S. Callow (Chairman), Mr. J. E. Edgecombe, Mr. J. W. Elliott (Secretary), Mr. J. Y. Fletcher, Mr. F. W. Willcox.

Committee on Papers and Editing.*

Mr. A. P. Trotter (Chairman), Mr. F. W. Goodenough, Dr. W. M. Bayliss, Mr . Haydn T. Harrison, and Mr. P. J. Waldram.

Committee on Finance.*

Col. W. F. Leese (Chairman), Mr. J. W. Ife (Hon. Treasurer), Mr. F. W. Goodenough, Mr. Chas. W. Hastings.

Other Committees in course of formation :—

Committee on Progress in Gas Lamps and Lighting Accessories.

Committee on Office Lighting.

Committee on Stage Lighting.

Committee on Extension of Membership.

---

* *The President, Hon. Secretary and Assistant Hon. Secretary are ex-officio members of all Committees.*

Committees as at present constituted have power to co-opt, or to call as witnesses members of the Society or others whose knowledge or experience would be of benefit in their inquiries.

LIST OF OFFICERS AND MEMBERS OF COUNCIL

OF

The Illuminating Engineering Society.

President—A. P. Trotter, M.Inst C.E., M.I.M.E., M.I.E.E., Consulting Engineer, 11, Victoria Street, S.W.1.

Members of Council—

F. Bailey, Chief Engineer, City of London Electric Lighting Co., Ltd., 64, Bankside, London, S.E.

Prof. W. M. Bayliss, M.A., D.Sc., F.R.S., Assistant Professor of Physiology at University College, London, St. Cuthbert's, Hampstead Heath, London.

W. C. Clinton, Assistant Professor of Electrical Engineering, University College, London, 43, Stanhope Gardens, Highgate, London.

J. Darch, F.S.I., Surveyor, Mem. Roy. San. Inst., 55, West Side, Wandsworth Common, London, S.W.

J. S. Dow, Asst. Editor of *The Illuminating Engineer*, Mayfield, Shepherd's Hill, Highgate, London.

J. Eck, M.I.E.E., late Manager and Chief Engineer of the Union Electric Co., Park Street, Southwark, London, S.E.

J. E. Edgecombe, Director of the Electric Lamps Manufacturers of Gt. Britain, Ltd., 46, Queen Victoria Street, London, E.C.

L. Gaster, Consulting Engineer and Editor of *The Illuminating Engineer*, etc., 32, Victoria Street, London, S.W.

F. W. Goodenough, Mem. Inst. Gas Engineers, Sales Controller of the Gas Light and Coke Co., Horseferry Road, London, S.W. (*Deputy-Chairman.*)

Haydn T. Harrison, Electrical Engineer, 11, Victoria Street, London.

Dr. H. R. B. Hickman, M.A., M.B.(Oxon.), M.R.C.S., L.R.C.P., Ophthalmic Surgeon, 5, Harley Street, London, W., and White Hill House, Chesham, Bucks, England.

J. Wyatt Ife, Lighting Engineer, 12, Carteret Street, London, S.W.

Dr. James Kerr, Medical Officer, London County Council Education Offices, Public Health Dept., Room 23, 2, Savoy Hill, Victoria Embankment, London, W.C.

Col. W. F. Leese, Director of Brompton Electricity Co., The Costa Rica, and the Rosario Electric Cos., etc., 17, Carlton Road, Ealing.

Lt.-Col. F. A. Cortez Leigh, Chief Electrical Engineer, London and North Western Railway, Euston Station, London, N.W.

Dr. R. Lessing, Ph.D., F.C.S., Consulting and Analytical Chemist, Southampton House, 317, High Holborn, London.

Dr. A. H. Levy, M.D., F.R.C.S., etc., Ophthalmic Surgeon, Central London Ophthalmic Hospital, etc., 67, Wimpole Street, Cavendish Square, London, W.

O. P. Macfarlane, Managing Director of Blanchard Lamps, Ltd., 35, King's Avenue, Muswell Hill, London, N.

W. R. Rawlings, Electrical Contracting Engineer, Past President of the Electrical Contractors' Association, 82, Gloucester Road, South Kensington, London, S.W.

A. Stokes, Chief Outdoor Inspector of the South Metropolitan Gas Company, 709, Old Kent Road, London.

S. E. Thornton, Chairman of Messrs. W. Sugg & Co., Sanctuary House, Tothill Street, London, S.W.

A. P. Trotter, M.Inst.C.E., M.I.M.E., M.I.E.E., Consulting Engineer, 11, Victoria Street, London, S.W. (*President and Chairman of Council.*)

P. J. Waldram, F.S.I., Surveyor and Civil Engineer, Robins Croft, Second Avenue, Hendon.

Hon. Secretary—L. Gaster. *Secretary*—J. S. Dow. *Hon. Treasurer*—J. Wyatt Ife.

Hon. Solicitors—Messrs. G. M. Light & Fulton, 1, Laurence Pountney Hill, Cannon Street, London, E.C.

In addition the Acting Presidents of the following bodies become members of Council of the Illuminating Engineering Society during their terms of office:—

The Illuminating Engineering Society in the United States; The Illuminating Engineering Society in Japan; The Institution of Gas Engineers; The Institution of Electrical Engineers; The Council of British Ophthalmologists; The Ophthalmological Society; The Physiological Society; The Electrical Contractors' Association; The Association of Railway Electrical and Telegraph Engineers.

LIST OF PAPERS READ BEFORE

The Illuminating Engineering Society

(Founded in London),

1909—1919.

1909.

Nov. 18 Inaugural Address. By Prof. Silvanus P. Thompson.

1910.

Jan. 11 & Feb. 15 Glare, Its Causes and Effects. By J. Herbert Parsons.

Discussed by :—

Great Britain—Dr. F. W. Edridge Green, Dr. F. Gans, Dr. J. Kerr, Dr. W. Ettles, Dr. T. M. Legge, Dr. W. M. Bayliss, Mr. P. J. Waldram ; A. P. Trotter, J. H. Agar Baugh, J. S. Dow, W. R. Cooper, W. M. Mordey, Haydn T. Harrison, V. H. Mackinney, L. Gaster, Dr. S. P. Thompson, Dr. E. H. Nash, Dr. W. Ettles, Prof. G. J. Burch.

Abroad—Dr. K. Stockhausen (Dresden), Prof. L. Weber (Kiel), Dr. Corsepius (Cologne), Dr. L. Bell (Boston), Dr. E. P. Hyde (Cleveland), Prof. R. Ulbricht (Dresden), Dr. L. Bloch (Berlin), M. Lauriol (Paris), Prof. S. A. Rumi (Genoa), Dr. W. H. Seabrook (New York), Dr. E. O. Sisson (Denver), Dr. W. Voege (Hamburg), Dr. H. Krüss (Hamburg), Prof. H. Strache (Vienna), H. Prenger (Cologne), Dr. H. Lux (Berlin), Prof. A. Grau (Vienna), Messrs. Körting and Mathiesen (Berlin), C. H. Williams (Boston) (19).

Mar. 15 & April 14 The Measurement of Light and Illumination (General Discussion).

Discussed by :—

Great Britain—Prof. A. E. Vernon Harcourt, Dr. J. A. Fleming, A. P. Trotter, C. C. Paterson, Dr. W. E. Sumpner, W. J. Liberty, Prof. J. T. Morris, J. S. Dow, L. Wild ; J. G. Clark, Haydn T. Harrison, P. J. Waldram, K. Edgcumbe, L. Gaster, W. R. Cooper, G. F. Boxall (16).

Abroad—Dr. K. Stockhausen (Dresden), Dr. L. Bell (Boston), Dr. C. H. Sharp (New York), G. H. Stickney (Schenectady), F. Lauriol (Paris) ; Prof. A. Blondel (Paris), Dr. Corsepius (Cologne), W. J. Cady (New York), A. A. Wohlauer (New York), N. Macbeth (New Jersey) (10).

April 14 The Direct Measurement of the Total Light Emitted from a Lamp. By Dr. W. E. Sumpner (6).

Nov. 8 Recent Progress in and the Present Status of Gaslighting. By F. W. Goodenough (13).

Dec. 9 Recent Progress in Electric Lighting. By Dr. W. E. Marchant.
Note on the Blackening of Tungsten Lamps. By G. W. Howe. (16)

1911.

Jan. 16 & Jan. 31 The Artificial Lighting of Libraries. By J. Duff Brown, L. S. Jast, J. Darch. (25)
(Joint Meeting with the Library Association.)

Feb. 16 The Natural Lighting of Schools. By Dr. J. Kerr.
The Artificial Lighting of Schools. By Dr. N. Bishop Harman. (25)
(Joint Meeting with the Association of Medical Officers in Schools, the London Teachers' Association, and the Association of Technical Institutions.)

April 24 Interior Illumination and the Reflecting Power of Walls and Ceilings. By Haydn T. Harrison and P. J. Waldram. (12)

Nov. 17 Notes on the Design of Motor-Car Headlights. By Dr. H. R. B. Hickman. (10)

Dec. 19 Lighting of Railway Stations and Goods Yards. By Haydn T. Harrison. (15)

[*The numbers in parentheses at the end of each reference indicates the number of persons taking part in the discussion.*]

List of Papers read before the Illuminating Engineering Society—(*continued*) :—

1912.

Jan. 16 Colour Discrimination by Artificial Light. By T. E. Ritchie. (15)
Feb. 20 Shop Lighting by Electricity. By N. W. Prangnell.
Shop Lighting by Gas. By A. E. Broadberry. (16)
Mar. 19 Illumination of Printing Works by Electricity. By J. Eck.
Illumination of Printing Works by Gas. By F. W. Goodenough. (11)
April 15 Private House Lighting by Electricity. By W. R. Rawlings.
Private House Lighting by Gas. By W. H. Y. Webber. (12)
Nov. 19 Recent Progress in Illuminating Engineering. By L. Gaster.
A New Illumination Photometer. By Haydn T. Harrison.
Photography in Illuminating Engineering. By J. S. Dow.
Apparatus to Illustrate Reflection from Walls and the Ceiling. By Prof. W. C. Clinton. (12)
Dec. 3 Modern Methods of Indirect Lighting. By F. W. Willcox and H. C. Wheat. (14)

1913.

Jan. 14 Acetylene Lighting. By C. Hoddle.
Petrol-Air Gas Lighting. By E. Scott Snell. (15)
Feb. 18 Some Notes on the Use of Shades and Reflectors. By J. G. Clark and V. H. Mackinney. (14)
Mar. 11 The Centenary of Gas Lighting and its Historical Development. By W. J. Liberty. (5)
April 15 & April 29 Standard Clauses for Insertion in a Specification of Street-lighting. By A. P. Trotter.
Discussed by :—

Great Britain—W. H. Patchell, F. W. Goodenough, Haydn T. Harrison, R. Watson, J. G. Clark, F. Thorp, K. Edgcumbe, J. Darch, H. T. Wilkinson, Prof. J. T. Morris, J. W. Bradley, F. Bailey, E. Allen, Roger T. Smith, W. R. Cooper, J. Abady, L. Gaster, N. W. Prangnell, S. L. Pearce, H. A. Ratcliff, J. G. Clark, J. S. Dow, W. J. Liberty (23).

Abroad—Dr. L. Bloch (Berlin), Dr. L. J. Terneden (Amsterdam), Prof. H. Strache (Vienna), Prof. S. A. Rumi (Genoa), Dr. L. Bell (Boston), L. B. Marks (New York), Dr. C. H. Sharp (New York), P. S. Millar (New York). (8)

Nov. 18 Report of Progress during Vacation. By L. Gaster.
Illumination at the National Gas Exhibition. By F. W. Goodenough.
Some Notes on the Fourth International Congress of School Hygiene. By Dr. James Kerr.
Shadows by Natural and Artificial Light. By J. S. Dow and V. H. Mackinney. (5)
The Importance of Direction, Quality and Distribution of Light. By M. Luckiesh.
Dec. 16 Some Problems in Daylight Illumination. By P. J. Waldram.

1914.

Jan. 15 Discussion of above paper :—

Great Britain—G. Widdows, Dr. J. Kerr, J. S. Dow, F. R. Farrow, Dr. E. H. Nash, A. P. Trotter, W. C. Clinton, H. L. Dunstall, C. C. Paterson, P. L. Marks, W. H. Webb, Dr. F. Gans, J. S. Dow, V. H. Mackinney, L. Gaster, T. E. Ritchie, L. Warren, P. J. Waldram (18).

Abroad—Prof. L. Weber (Kiel), Dr. F. Pleier (Karlsbad), Dr. L. Burgerstein (Vienna), Dr. F. Altschul (Prag), Dr. Erisman (Zurich), Dr. Kaz (St. Petersburg), Prof. Richtmeyer (Ithaca, U.S.A.), Dr. Max Grüber (Munich) (8).

Feb. 17 The Lighting of Picture Galleries and Art Studios. By Prof. Silvanus P. Thompson. (15)
Mar. 17 A Comparison of Estimated and Observed Values of Illumination in Some Lighting Installations. By W. C. Clinton. (13)
April 7 The Lighting of Railway Carriages and other Public Vehicles (Discussion). (9)

List of Papers read before the Illuminating Engineering Society—(*continued*) :—

May 21 THE NOMENCLATURE AND DEFINITION OF PHOTOMETRIC MAGNITUDES AND UNITS. By A. P. TROTTER.

Discussed by :—

Great Britain—Dr. S. P. Thompson, C. C. Paterson, Haydn T. Harrison, F. W. Goodenough, W. C. Clinton, E. Allen, K. Edgcumbe, J. T. Morris, W. J. A. Butterfield, J. Darch, W. J. Liberty, V. H. Mackinney, A. V. Belltell, Dr. A. Schuster, J. S. Dow, W. R. Cooper, J. W. T. Walsh (17).

Abroad—Dr. L. Bell (Boston), Prof. A. Blondel (Paris), Prof. Dr. H. Bunte (Karlsruhe) (3).

Dec. 1 ILLUMINATING ENGINEERING IN WAR TIME. By L. GASTER. (10)

1915.

Jan. 19 SEARCHLIGHTS, THEIR SCIENTIFIC DEVELOPMENT AND PRACTICAL APPLICATION. By P. G. LEDGER. (15)

Feb. 16 THE DEVELOPMENT AND DESIGN OF LIGHTING FIXTURES IN RELATION TO ARCHITECTURE, INTERIOR DECORATION AND ILLUMINATION. By F. W. THORPE. (17)

Mar. 16 THE RATING AND GRADING OF LAMPS AND THE BEST METHODS OF SPECIFYING THEIR ILLUMINATING VALUE. By F. W. WILLCOX. (20)

April 27 VISIBILITY: ITS PRACTICAL ASPECTS. By C. C. PATTERSON and B. P. DUDDING. (11)

May 18 SOME POINTS IN CONNECTION WITH THE LIGHTING OF RIFLE RANGES. By A. P. TROTTER.

Discussed by :—

A. Blok, A. Schamasch, P. J. Waldram, H. Brazil, Col. Gaitskell Burr, H. Freak, W. J. Bassett, G. Herbert, the Commandant of the Royal School of Musketry, Hythe, F. Bailey, S. G. Coram, T. B. Pickard, J. G. Clark, W. Ettles, the Commandant of Royal Marines Depot, Deal, J. S. Dow, Frank West (Hon. Secretary of Rifle Club at the India Office) (17).

Nov. 23 NOTES ON THE FIRST REPORT OF THE DEPARTMENTAL HOME OFFICE COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS. By L. GASTER. (12)

Dec. 10 RECENT DEVELOPMENTS IN ELECTRIC INCANDESCENT LAMPS IN RELATION TO ILLUMINATING ENGINEERING. By PROF. J. T. McGREGOR MORRIS. (8)

1916.

Jan. 11 SOME PRINCIPLES IN INDUSTRIAL LIGHTING. By J. S. DOW. (12)

Feb. 22 SOME FUTURE POSSIBILITIES IN THE DESIGN OF INSTRUMENTS FOR MEASURING ILLUMINATION. (17)

Mar. 31 SOME ASPECTS OF THE DESIGN AND USE OF GLASSWARE IN RELATION TO NATURAL AND ARTIFICIAL ILLUMINATION. By S. B. LANGLANDS. (21)

May 9 INTERIM REPORT OF THE COMMITTEE ON RESEARCH.

Dec. 15 SOME EVENTS DURING THE VACATION WITH SPECIAL REFERENCE TO WAR ECONOMIES IN LIGHTING. By L. GASTER. (7)

1917.

Jan. 16 THE LUMEN AS A MEASURE OF ILLUMINATING POWER. By PROF. J. T. McGREGOR MORRIS, F. W. WILLCOX. (15)

Feb. 20 THE EFFECT ON THE EYE OF VARIOUS DEGREES OF BRIGHTNESS AND CONTRAST. By DR. JAMES KERR.

(The Cinema Commission of Enquiry was represented at this discussion.)

Discussed by :—

Sir William Bennett, Dr. Ernest Clarke, M.P., F.R.C.S., N. Bishop Harman, Colin N. Bennett, E. G. Kennard, Dr. C. W. Kimmins (Member of the Cinema Commission of Enquiry); L.C.C. Chief Inspector of Schools), A. E. Newbould (Member of the Cinema Commission of Enquiry), F. W. Goodenough, Dr. F. W. Edridge Green, E. T. Swinson, Lieut. S. R. Mullard, R.N.V.R., Mrs. M. A. Cloudesley Brereton, A. Cunnington, J. G. Clark, A. P. Trotter, J. W Barker, J. S. Dow, L. Gaster (18).

List of Papers read before the Illuminating Engineering Society—(*continued*) :—

Mar. 22 FLUORESCENCE AND PHOSPHORESCENCE AND THEIR USE TO PRODUCE LUMINOUS EFFECTS. By F. HARRISON GLEW, J. S. DOW, ARTHUR BLOK. (4)
May 15 ECONOMIES IN LIGHTING IN RELATION TO FUEL SAVING. (5)
Dec. 18 PRESIDENTIAL ADDRESS. By A. P. TROTTER.

1918.

Jan. 15 TEN YEARS OF ILLUMINATING ENGINEERING. ITS LESSONS AND FUTURE PROSPECTS. By L. GASTER. (6)
Feb. 26 A SURVEY OF METHODS OF DIRECTING AND CONCENTRATING LIGHT. By Lt.-Commander HAYDN T. HARRISON. (13)
April 16 LIGHT AND VISION, THE PHYSIOLOGY OF THE RETINA. By PROF. W. M. BAYLISS.
(Co-operation of Physiologists and Ophthalmists specially invited.)
Discussed by :—

E. Treacher Collins (President of the Ophthalmological Society), Col. J. Herbert Parsons, Dr. F. W. Edridge Green, Dr. James Kerr, Lieut.-Col. R. H. Elliott, Dr. J. F. Crowley, S. Taylor, R. P. Howgrave Graham, A. P. Trotter, L. Gaster, W. C. Clinton, J. S. Dow (12).

May 14 RECOMMENDATIONS ON ECONOMY IN LIGHTING. (9)
Dec. 19 PHOTOMETRIC APPARATUS FOR MEASURING THE ILLUMINATING VALUE OF FLUCTUATING SOURCES OF HIGH CANDLEPOWER (Flares, Parachute Lights, etc.). By A. P. TROTTER.
SOME PHOTOMETRIC TESTS OF THE BRIGHTNESS OF RADIOACTIVE SELF-LUMINOUS MATERIALS. By W. C. CLINTON.
Discussed by :—

W. C. Clinton, J. S. Dow, C. C. Paterson, Capt. G. Gray (M.O.M. Chemical Warfare Dept.), F. F. S. Bryson (M.O.M. Optical Munition and Glassware Supply), F. Harrison Glew, J. W. T. Walsh, A. Blok, Mrs. Hutha Ayrton, L. Gaster, A. L. Landau (11).

1919.

Jan. 21 MODERN PRACTICE IN OFFICE LIGHTING. By A. WISE. (11)
Feb. 25 SOME NOTES ON RAILWAY LIGHTING AND ITS MAINTENANCE. By A. CUNNINGTON.
(Co-operation of Railway Engineers specially invited.)
Discussed by :—

Haydn T. Harrison, J. H. Haigh (Lancashire and Yorkshire Railway), A. H. Stevens (London and North-Western Railway), P. Whysall (Underground Electric Railways, Ltd.), H. Perkin (Great Central Railway), F. W. Goodenough, A. Wise, H. E. Robarts (South-Eastern and Chatham Railway), A. P. Trotter, L. Gaster, H. I. Bond (London and South-Western Railway), N. W. Prangnell, E. S. D. Moore (London and North Western Railway), M. Macdonald (Great Western Railway), C. R. Williams (15).

April 8 THE ART OF STAGE LIGHTING. By J. B. FAGAN (Royal Court Theatre).
(Meeting arranged in co-operation with the "Critics' Circle" of the Institute of Journalists.)
Discussed by :—

William Archer, T. J. Digby, G. E. Morrison (Chairman, "Critics' Circle"), N. R. Booth, Mrs. K. Searle, N. McDermott (Everyman Theatre), J. W. T. Walsh, Howgrave Graham, Lane Crawford (Britannia Theatre), W. G. Raffé, J. Darch, A. P. Trotter, L. Gaster, G. A. Applebee, J. S. Dow, Gordon Craig (16).

May 30 THE GAS-FILLED LAMP AND ITS EFFECT ON ILLUMINATING ENGINEERING. By F. W. WILLCOX. (15)
(Meeting arranged in co-operation with the Electric Contractors' Association, the Association of Supervising Electricians, and the Association of Engineers in charge.)
June 24 STREET-LIGHTING RECONSTRUCTION PROBLEMS. By L. GASTER. (7)

N.B.—In the case of subjects on which much difference of opinion exists, or where the co-operation of corresponding members, kindred societies, or experts outside the ranks of the Society was secured, we are including the names of those who joined in the discussion, in order to illustrate the wide circle of experts interested in the work of the Society.—ED.

STREET-LIGHTING RECONSTRUCTION PROBLEMS.

By L. Gaster.

(Introduction to a discussion at the Annual Meeting held at the House of the Royal Society of Arts at 8.15 p.m., on Tuesday, June 24th, 1919.)

Street-lighting problems were receiving much attention at the hands of members of the Society shortly before the war, notably in the paper dealing with the Standard Clauses for insertion in a Street Lighting Specification read by the President (Mr. A. P. Trotter), on April 15th, 1913, while the Author, in a paper on "The Lighting of London," read before the London Society on February 10th, 1914, made a plea for the treatment of the lighting of this city as a whole, and on a uniform basis. In view of the prospect of future reconstruction work in street lighting, the moment is ripe to review experience during the past five years, and consider future developments.

Experience during the War.

The treatment of street lighting in London during the War falls into three distinct periods. There was *first* a progressive and somewhat indiscriminate diminution in light by reducing the number of lamps lighted, and restricting the pressure of electricity or gas supplied to them; *secondly*, a period when further diminutions were made by masking lights so that only a narrow cone of light was shed on the roadway in the vicinity of lamps; *thirdly*, the period when the Authorities, acting on expert advice, substituted diffused lighting, by coating a portion of the lanterns with white distemper. The latter method helped to eliminate the objectionable contrasts in brightness and produced a more uniform effect. Immediately after the Armistice a fourth period was entered upon, the restrictions relating to screening being withdrawn and pre-war lighting rendered permissible, subject to 50 per cent. reduction in the interests of economy. It is anticipated that this last restriction will also be withdrawn in the near future, after the signing of Peace.

In the revulsion from these restrictions people are naturally inclined to a restoration of pre-war conditions. But we should seek to profit by the experience of the past years and aim not merely at restoration but improvement in street lighting. From this experience two points stand out prominently:—(1) The value of diffusing appliances in lessening glare and excessive contrasts in brightness; (2) the desirability of uniformity of practice as regards the principles of street lighting throughout the entire Greater London area.

It is curious that in many respects the necessities of war imposed practices which this Society long ago advocated on other and general grounds. We may instance, for example, the enforced shading of bright lights in shop windows and the tendency towards diffused lighting for public lamps and the general recognition that a uniform order of illumination was desirable as a military measure as well as from the illuminating engineering standpoint.

Street Accidents and Public Lighting.

From the official data as at present presented it is difficult to draw definite conclusions regarding the effect of diminished lighting in causing street accidents. During the war period accidents at first increased greatly, but subsequently diminished in the latter part of 1918, when the lighting was improved. In the period 1913-1915 fatal accidents increased 34 per cent. by day, but 63 per cent. by night; and non-fatal accidents 6 per cent. by day and 21 per cent. by night. This indicates that diminished lighting was a contributory factor. The author has recently drawn up a schedule for the collection of data on a uniform basis, enabling the relation between public lighting and accidents to be traced.* Owing to depleted staff and pressure of special work, the authorities were unable to undertake the suggested collection of statistics during the war and much valuable information has thus been lost. But there is still time for this schedule to be applied to the reconstruction period.

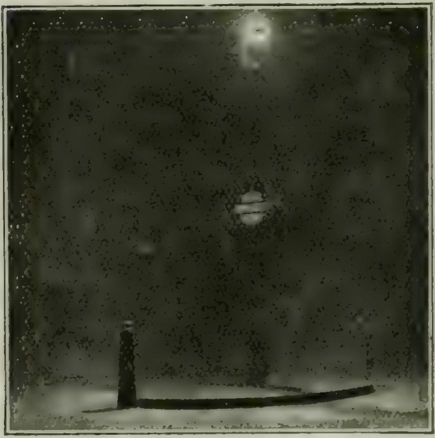


FIG. 3.—Night view near Mansion House during the war. The cone of light is seen immediately under lamp.

Public Lighting and Traffic Conditions.

During the war a great stimulus to the study of street lighting in relation to traffic has been given by the work of the Lighting Sub-Committee of the London "Safety First" Council, on which the Society is represented. Among others, the following points have been emphasised : (*a*) the desirability of using diffusing glassware on street lamps installed in the reconstruction period; (*b*) the planning of street lighting in such a way as to avoid extreme contrasts in illumination in passing from a side street to a main street, or in passing from one borough to another; (*c*) the provision of special lighting to facilitate the guidance of traffic, *e.g.*, at important crossings, dangerous turnings, etc.; (*d*) the provision of light at regular stopping places for vehicles, and, in the case of buses, the selection of stopping places at points where a street lamp is lighted; (*e*) that in restoring street lighting, attention should be devoted first to important routes of traffic; (*f*) the desirability of consultation among local authorities with a view to uniformity of practice in regard to street lighting, and (*g*) the survey of thoroughfares with a view to their classification according to the Standard Specification for Street Lighting in order of importance and illumination requirements.

At present streets of equal importance as carriers of traffic are treated quite differently in various districts. The plan laid down in the Standard Specification for Street Lighting, according to which streets are divided into five classes according to their importance, and a certain minimum illumination from 0·01 up to 0·06 foot-candles specified according to class, affords a good basis for inquiry. Let us, therefore, have each district surveyed and the class of the chief thoroughfares settled. Next, let us ascertain whether the illumination comes up to the prescribed level, and if not, what steps should be taken to improve matters. There are, of course, certain thoroughfares (such as Cheapside, Whitehall and Regent Street) where the

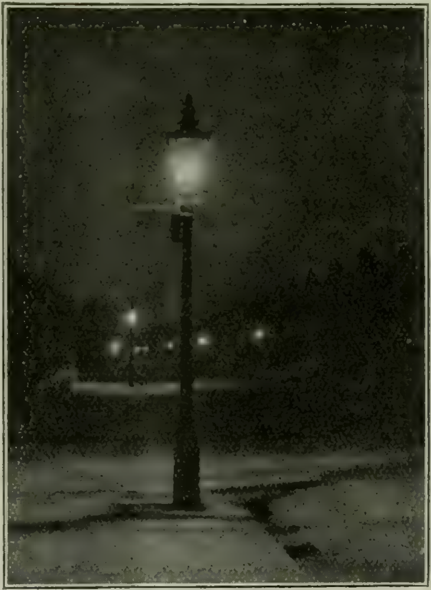


FIG. 4.—Night view of a suburban street (Tottenham) during the war, showing effect of black band round lantern and clear lower portion.

---

* ILLUM. ENG., Jan., 1918, p. 14.

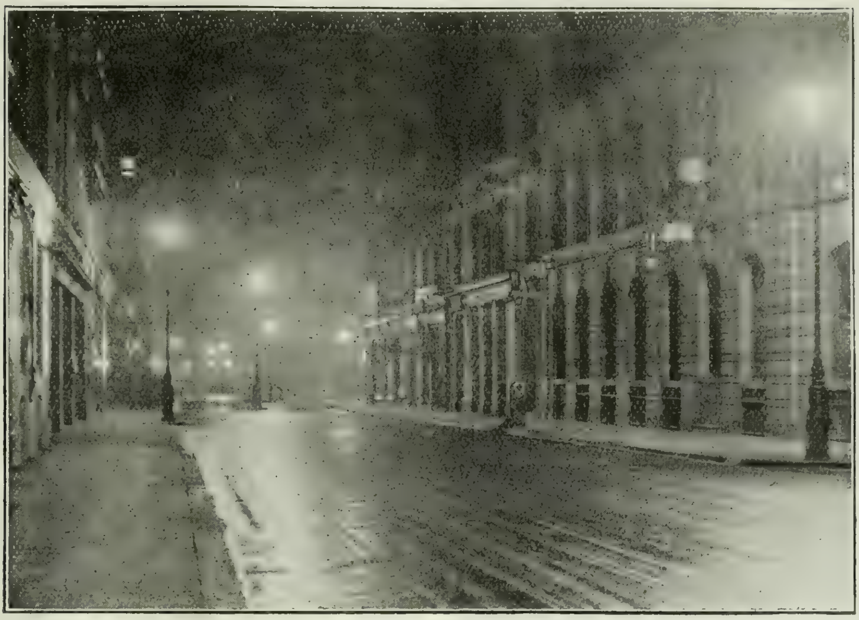


FIG. 1.—Night View of Queen Victoria Street, London. Pre-war high-pressure gas lighting.

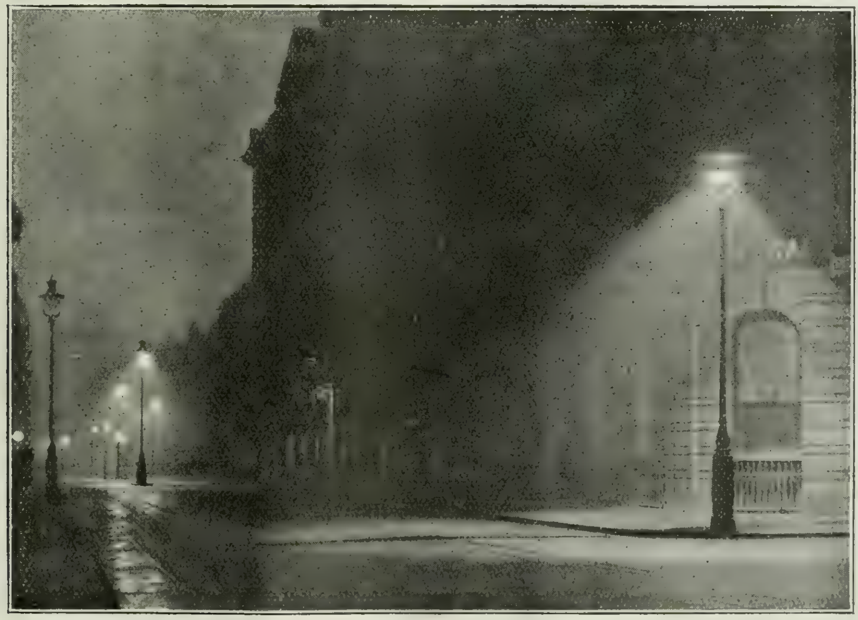


FIG. 2.—Night view of same street during war time. The masking of the lights gave rise to a cone of light below each lamp and marked contrasts in the illumination on the roadway and pavement. (There was some moonlight at the time the photograph was taken, hence the street was really darker than the illustration suggests.)

minimum illumination, on the pre-war basis, amounts to 0·1 foot-candles or even more, but these are quite exceptional and their brilliant lighting only serves to accentuate the poor lighting in adjacent streets and squares.

Furthermore, the nature of the duties which a street fulfils must be taken into account. There are some streets which are important in virtue of their position, and yet do not carry a very heavy traffic or are used almost exclusively by fast-moving motor-vehicles following each other at a fairly rapid speed but without congestion. Thus the Embankment, with its constant stream of tramcars, needs good lighting, and in view of its commanding position by the side of the river artistic effect should have special consideration. But the traffic is rarely congested. On the other hand such city roads as Upper Thames Street, which is relatively narrow and, being an essentially commercial thoroughfare, hardly demands very artistic treatment; nevertheless it needs special consideration because the traffic, though slow, is apt to become congested. There are frequently vans unloading at warehouses in this street. Other ways, such as the main avenues in the Green Park, Cromwell Road, and its continuation past the South Kensington Museum convey essentially fast driven non-commercial traffic, and, by reason of their position, demand special consideration from the æsthetic standpoint.

I must also guard against the assumption that the mere provision of a certain minimum or average horizontal illumination in a street is the *only* point to consider. Both on æsthetic grounds and in order to eliminate glare I consider the use of diffusing glassware of equal importance. To my mind the time is coming when we shall accept in street-lighting the same general principle as is already recognised in good interior lighting, that no naked mantle or filament shall fall within the ordinary range of vision. The prospective wide applications of high candlepower gas-filled lamps to street lighting makes this a matter of special importance.

During the war the darkened conditions of the streets have strongly emphasised the necessity of reducing intrinsic brilliancy by this means, and this leads me to say a few words on lighting effects during the coming peace celebrations.

Illuminations in Celebration of Peace.

During the period of celebration of the signing of peace it is desirable that brilliant unshaded lights at a low level, such as are apt to distract the attention of drivers and pedestrians and prove prejudicial to traffic, should not be used, but instead concealed lights employed to illuminate suitable mottoes, emblems, etc. Such devices might also preferably be used instead of flashing signs; or, if the latter are used, they should be situated at a high level, out of the direct range of vision of persons in the street. One of the best Peace-mementoes would be the placing of the lighting of London on a more satisfactory and uniform basis. Among other measures the permanent lighting by concealed lamps of public monuments serving as mementoes of the war may be suggested. The fact of this lighting effects being necessarily installed at short notice and the present shortage of labour and materials makes it difficult to scheme out any elaborate plan and most householders will have to be content with makeshift devices. But there are some things that might be done to secure a suitable decorative effect without interfering with the guidance of traffic. If, for example, the lights in all offices and buildings facing on main thoroughfares were left lighted, and the windows covered by transparencies carrying appropriate mottos, devices, etc., the resultant diffused illumination would be helpful and not prejudicial to the safety of traffic. Such methods also *convey some idea* which the mere exhibition of a light does not.

General Problems in Street Lighting.

Among other questions that require study may be mentioned: (1) The choice of illuminant; (2) the mode of lighting, *e.g.*, by centrally suspended lamps, staggered posts, posts in centre of road, combination of central suspended lights and side lights; (3) the distribution of light, *i.e.*, the percentage of light from public lamps that should be directed on the street surface; (4) the design of fittings, fulfilling satisfactorily the dual purpose of diminishing glare and achieving uniformity of illumination; (5) the extent to which private lighting (*e.g.*, exterior lamps outside shops, theatres, places of entertainment, etc.) can be co-ordinated with street lighting so as to be an aid and not a menace to traffic. Some degree of supervision over such private lighting is essential in order that they may not be in conflict with the intentions of public lighting.

Much remains to be done in the design of fittings, especially for use with the gas-filled lamp, which will doubtless be largely used for future street lighting. The distribution of light needs special care, but there is general agreement that the greater part of the light should be directed on the roadway, where it is chiefly needed. Street lighting requirements are now quite different from what they were a few years ago in view of the great increase in the volume of traffic and the high speed of motor vehicles. Regulations relating to head-lights for such vehicles will need careful framing, and this Society would be prepared to be of assistance in this matter.

In the interests both of drivers and of persons walking on the pavement, the provision of a good illumination on the street-kerb is most desirable. This point should be taken into consideration in weighing the advantages of posts erected along the edge of the pavement or central lamps. The latter has also the drawback that, unless supplemented by lamps at the side of the road, it may not effectively illuminate the sides of vehicles. The latter are apt to be seen as a "silhouette" against reflected light from the roadway, rather than by the illumination they themselves receive. Moreover, central lights are more apt to fall directly in the range of vision of drivers. Against this the freedom from posts attained with centrally suspended lights is undoubtedly an advantage.

Among the above problems Nos. (3) and (4) are the most debatable, as going to the root of modern practice in street-lighting. There has been much discussion as to the proportion of light to be allotted to the street-surface. While much is to be gained by even a weak illumination of surrounding buildings, as contrasted with complete obscurity, I think opinion generally recognises that *most* of the light from a street-lamp should fall on the pavement and roadway. In street-lighting we are still far below the desirable amount of light, even in the best illuminated streets, and the present limit to the amount of illumination provided is set chiefly by the permissible expenditure. It is therefore very important to make the best use of this light. Moreover, with all the ordinary methods of street-lighting, the provision of adequate light on the road and pavement necessarily involves a certain amount of light falling on the lower parts of buildings and on the vertical surfaces of vehicles. Assuming that all light is directed below the horizontal it is only the upper portions of buildings that receive practically no light. I think, therefore, it may be conceded that, with our present resources in street lighting, (a) no light should be directed upwards (above the horizontal) from street lamps, and (b) of the light directed downwards by far the greater portion should strike the road and pavement.

We next pass to another point. Assuming that most of the available light is thrown on the roadway, is it desirable that the illumination between lamp-posts should (if possible) be substantially uniform ? Here again I think it is now generally conceded that theoretically any point between two successive lamp-posts is equally important and should receive the same illumination ; certainly very wide variations in illumination, exceeding a range of 1 to 100, should be avoided. In practice, however, it is extremely difficult to avoid wide variations in illumination, and this difficulty increases as the distance between successive lamps becomes greater. The survey carried out by the Joint Street Lighting Committee showed that even in streets considered well lighted, variations of more than 1 : 50 may exist.

One of those who did much pioneering work on this subject was Mr. A. J. Sweet, who has furnished me with some diagrams showing the ideal form of polar curve to produce uniform illumination, with various ratios between height of lamp and distance between lamps. By some of the latest prismatic refractor street lighting units such ideal curves may be approached. One cannot, however, select the distance between lamps at will in practice, and can hardly expect to obtain results possible by theoretical design. Inspection of these ideal polar curves also reveals another difficulty. The even illumination is only obtained by strongly accentuating the candlepower at angles slightly below the horizontal, and it is just at these angles that the light is most liable to strike into the eyes of approaching drivers or pedestrians and cause dazzle. We are thus faced by the problem how far is it desirable, in the interests of uniform illumination, to produce conditions which may accentuate glare? In the street lighting units referred to an attempt is made to meet this difficulty by the special design of the prismatic glass surfaces which, besides making the desired alteration in the polar curve, also diffuse the light and reduce its intrinsic brilliancy. The Holophane street-lighting unit, with its ingenious combination of prismatic surfaces, offering both a smooth interior and a smooth exterior surface, is one of the most striking examples of such attempts. I would suggest this further consideration, that if, in order to avoid glare, a considerable departure from the ideal uniform illumination between posts is allowed, the transition from the *brighter to the dark illumination should be as gradual as possible*. In this case the eye can accommodate itself to the variation in illumination, and even be unaware of it. The vital thing in street-lighting is to avoid sudden contrasts in brightness. Owing to the great increase in the volume and speed of traffic street-lighting requirements are now quite different from what they were a few years ago. A motor-car travelling at 10 miles per hour, traverses roughly 15 feet per second. If, during this second, the driver passes from a brightly lit area into one of relative darkness, if a bright street-lamp or opposing headlight suddenly come into view—in short, if any violent contrast in brightness is experienced, an accident is liable to occur.

Motor-car Headlights.

The last remark leads me to refer incidentally to another matter which requires to be considered in conjunction with street-lighting—the design of motor-car headlights. Here we meet again a difficulty not unlike that encountered in designing street-lighting units, which again requires compromise. In order that the road-surface may be illuminated ahead of the car sufficiently for the driver to see approaching vehicles or persons, a high beam candlepower is inevitable. This high candlepower, however, unavoidably involves some degree of glare. The drafting of regulations relating to motor-car headlights, which may be expected to receive attention in this country in the near future, therefore needs great care. This Society will doubtless be glad to be of service in advising the authorities on the problem. During the last few years the matter has been much discussed in the United States, where considerable variations in the legislation imposed by the various States exist. The matter has already received some attention from the London "Safety First" Council during the war. Of special interest also are the regulations recently adopted by the New York State, based largely on tests conducted by the American Illuminating Engineering Society.

Lighting of Arterial Roads, Important Thoroughfares, Public Squares, Parks, etc.

It is admitted that the lighting of London has developed chaotically. In many cases the lighting provided is determined by extraneous factors and even caprice, rather than by the reasoned study of what the road demands. This is illustrated by the sudden transitions from one system to another, even along one and the same thoroughfare. The matter is of special consequence in connection with arterial roads. Thus a person travelling from the Mansion House westwards along the Cheapside—Newgate Street—Holborn—New Oxford Street—Oxford Street—Bayswater Road artery meets many different systems of lighting and sudden transitions in the amount of illumination provided. Proceeding eastward along the Aldgate High Street—Mile End Road—Whitechapel Road route, he meets similar inconsistencies. Occasionally, as in the case of Whitehall, sudden changes both in system and brightness take place within a short length of street. In proceeding to an important square or traffic centre the illumination should increase gradually, there should be no sudden contrasts. The passage from the brilliant illumination of Whitehall to the subdued lighting of Parliament Square on the south or the irregular and varied methods of lighting in Trafalgar Square is in the nature of an anti-climax. The appearance of important streets and squares by night would be much improved by the proper planning of the lighting as a whole, and the design of more artistic forms of fittings and posts.

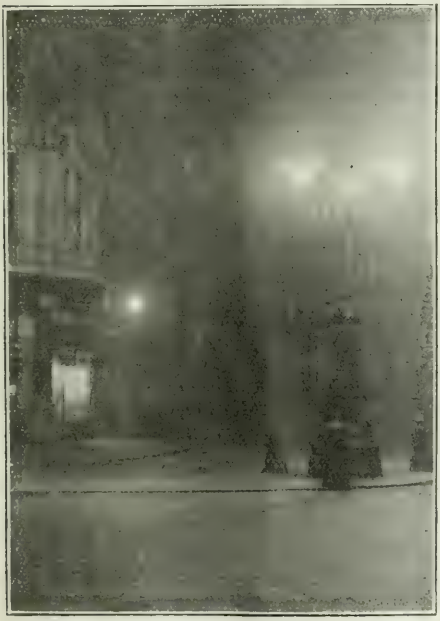


FIG. 5.—Gas-lamps in Trafalgar Square; pre-war lighting. These bright lights at a relatively low level form a great contrast to the lower order of illumination found in the upper part of Whitehall. During the initial period of the war only one of the lights, heavily masked, was left on, producing a "patchy" effect.

The lack of ordered system in lighting, and the failure to grasp opportunities of using this lighting to improve the appearance of the city by night is nowhere illustrated more strikingly than in the public parks. Trafalgar Square has been mentioned for the diversity of its lighting and the lack of any plan in the illumination of this world-famous centre in London. Passing from Trafalgar Square along the Mall we have a thoroughfare which, in pre-war days, was considered well lighted, the standards being favourably regarded as examples of sound artistic design. These standards are also grouped round the Victoria Memorial, where the illumination is still relatively high. But Constitution Hill is lighted by relatively low-candlepower, low-pressure gas lamps, and there is an abrupt transition in illumination as one turns up this avenue. At the Buckingham Gate, which is likewise lighted by low-pressure gas lamps (mounted in clear glass lanterns), there is again another transition as one passes out of the park. But the most curious feature is that the frontage of Buckingham Palace, the central point of interest in the park, is left in gloomy obscurity. There is no culminating point of interest as one passes from one end of the Mall to the other and the Victoria Memorial, which is intended to fill the eye as it looks along this long avenue, is invisible by night, though conspicuous by day. One could scarcely imagine a better case for the application of concealed spectacular lighting.

Public Education in Street Lighting.

It is evident that if the lighting of London is to make any substantial progress there must be a change in the estimation by the public of the importance of good street lighting. Members of the public, and even some of those who deal largely with the awarding of contracts for lighting streets, are apt to judge of the value of a lamp chiefly by its apparent brightness or glare, as viewed by the eye, rather than by the conditions of illumination it produces. Such misconceptions can only be removed by patient propaganda, and the history of the improved street-lighting in the City of Milwaukee, of which Mr. A. J. Sweet has kindly sent me some particulars, affords an interesting illustration. The preliminary step towards this change was taken in 1913, and Mr. A. J. Sweet undertook a great educational campaign in this city, upwards of a hundred popular lectures to various groups of citizens being delivered by him. Although there was originally some opposition. popular support for the proposed scientific lighting was ultimately secured by a three to one vote of referendum, the needed appropriation being 1,330,000 dollars (since increased to two million dollars owing to war prices). The city will own and maintain the entire system, and the installation is said to be the largest ever put through as a single street-lighting project in America. The Holophane refractor is used throughout. the distance between lamps being eight times the mounting height, and the diversity factor (ratio of maximum to minimum illumination) 4 to 1. Average horizontal illuminations will work out as follows :—

	Average horizontal illumination ft.-candles.
Main business streets ..	0·5
Secondary business streets ..	0·12
Main highways, not business streets	0·12
Residence streets	0·03

A feature of special interest is the relatively high posts units in main business streets, being 30 feet above the street. About half the installation is so far completed. Mr. Sweet has carried out a complete survey of the expenditure on street-lighting of every city in the United States of over 30,000 population. An average of all these figures, covering 204 cities, gives 0.75 dollars per head per annum, the highest (Buffalo) being slightly over one dollar per head. The old Milwaukee system cost 0.54 dollars per head, and the new system is to cost 0.77. The population has thus acceded to a considerable increase in cost in order to obtain better illumination. It is pointed out, however, that if the average American city were to raise its street-lighting to the values now adopted in Milwaukee an expenditure of 1.5 dollars per head would be required.

Co-ordination of Public and External Private Lighting.

A difficulty in street lighting is the darkness of surrounding surfaces, which prevents good diffusion of light, occasions sharp shadows, and accentuates the glare from light sources seen against this dark background. These conditions might be improved by co-ordination between public and private lighting. If suitably shaded and diffused such external privately installed lamps would yield valuable assistance to street lighting. Municipalities might consider co-operation with consumers in main thoroughfares, allowing a concession in charges if requirements as regards uniform procedure in equipping lamps is adopted. Similarly the appearance by night of important streets and squares would be much improved if some light, not necessarily a large amount, were allotted to the illumination by concealed lamps of public buildings, national monuments, etc. Another important factor is the illumination of nameplates for streets, and the more general use of mildly-illuminated plates indicating the nature of buildings would also be helpful.

Co-operation in dealing with the Lighting of London on a Uniform Basis.

In view of the concerted action taken by street-lighting authorities throughout London during the war, the moment is ripe to renew the suggestion for a continuation and extension of such co-operation in the future. For the moment it is suggested that an advisory committee should be formed, on which this Society, the London "Safety First" Council, and the chief authorities interested should be represented in order to prepare recommendations for the lighting of London on a uniform basis and in accordance with commonly acceptable principles, and to offer assistance in connection with any local problems that may arise.

It may be suggested that the matter might ultimately come under the supervision of the new Ministry of Ways and Communications working in co-operation with the bodies named above and also with the Royal Automobile Club, whose assistance would be valuable in dealing with the kindred problem of motor-car headlights, which, as we have seen, requires to be considered in conjunction with street lighting.

DISCUSSION.

The CHAIRMAN (Mr. F. W. Goodenough) said they were all very much indebted to Mr. Gaster for his long and very interesting discourse on street lighting reconstruction problems. He might almost say that it was not so much a discourse on the lighting of London as on the government of London, because all his criticism as to the diversity of the methods of lighting London was really a criticism of the diversity of our units of municipal administration. It might be said of the lighting of London what the American said of our climate, that we had not a climate, but only a collection of samples, but he would rather that Mr. Gaster tackled the problem of co-ordinating the government of lighting London than he himself. because he would have a life's task on his hands if he undertook that. Mr. Gaster had spoken of there being good reason for the difference of lighting, but he himself knew of no good reason other than the fact that there were fifty different local authorities dealing with the subject. It was suggested that the Minister of Ways and Communications—who would apparently have very little on his hands—should take on the problem of lighting the streets, he took it, from John o' Groats to Land's End, because traffic communications ran throughout the country ; but if the lighting of the roads was a matter that the Ministry of Ways and Communications should deal with, he did not see why the paving of the roads also should not come into their hands. They then began to remove the thoroughfares entirely from the control of the municipalities. In that he thought they were putting forward a very big proposition. Mr. Gaster spoke of the roadways from the Mansion House to Bayswater Road passing through six different authorities, and that accounted for the variations in the lighting.

With regard to the important question of not having too wide a variation between the maximum and the minimum lighting in the streets. his own comment on that—he believed he had made it before—was that a great deal depended upon what the minimum was. If the minimum lighting was sufficiently high, the extent of the variation did not matter. In daylight they got tremendous variations between minimum and maximum according to whether they were in shadow or in sun, but the fact that the lighting of the portion which was in shadow was sufficiently high, made the factor of variation unimportant. The point was to get an adequate minimum of lighting in the street. He quite agreed that kerb lighting was very important, and that always seemed to him a strong argument against centre lighting by itself, because with this form of lighting the traffic cast a shadow on the pavement. What was wanted was a combination of centre lighting and staggered sidewalk lighting. A great deal of stress was laid by Mr. Gaster on the shading of lamps in order to get diffusion. Personally he would say that that was unnecessary except above a certain candlepower of lamp. He did not think that anything under 250 or 300 candlepower needed to be shaded for the purpose of diffusion. It was only when they got to the more powerful lamps that this was necessary, otherwise they would be wasting a large amount of energy, first in giving a good light in the lamp and then in screening it down.

The lighting of public monuments depended a good deal upon what one's opinion was of the artistic value of the monuments of London. There were a good many monuments which he thought were better seen at night—the darker the better—and it would need the exercise of a good deal of discrimination as to which monument they would illuminate at night, and which they would leave to the kind obscurity of the darkness. Speaking seriously, however, a great difficulty would be cost. The cost of street lighting was bound to be on the rise with the increased cost of gas and electricity at the present time. and he was afraid it would be so for a long time to come. They would have rather a struggle to get the local authorities to continue to light the streets even as well as they had been lighted, with the extra cost, without suggesting to them that they should spend extra money in lighting the more or less artistic monuments in the streets.

With regard to the suggestion that in

street lighting they should co-operate with the shopkeepers, that presented certain difficulties in practice because the time during which the shopkeepers kept their premises illuminated did not at all coincide with the time that the streets were required to be kept well lighted. In London, for instance, there were many streets which had very heavy traffic after the time that the theatres broke up, whilst there were certain streets which had to be very well lighted all night because after the theatre traffic there was the incoming traffic to the markets. During the war they had also had the night ambulance traffic to deal with, but fortunately we did not have that now, but there was always some traffic going to the early morning markets, so that if we depended upon the efficiency of the lighting of the streets by co-operation with the shopkeepers we should find ourselves in difficulties.

He was afraid that Mr. Gaster would think that he was criticising all the way through, but after all the value of a paper was to start a discussion, and not merely for every one to say " ditto " ; therefore he had taken the other side and suggested some of the difficulties in connection with Mr. Gaster's proposals in regard to reform. He was quite with Mr. Gaster in feeling that the lighting of London and other cities needed greatly to be improved, and particularly in regard to London. If the author could co-ordinate the government of London and the lighting of London he would certainly be blessed by his fellow-citizens. He was sure they would all wish to thank Mr. Gaster very much for his paper, and if anybody had any questions to ask or would like to take part in the discussion, it was open to them to do so.

Mr. J. G. **Clark** said that although they had listened to a very excellent and interesting review of the situation regarding street lighting, he did not think that was the occasion for discussing the technicalities of such a vast and complicated problem. The war had taught us a good deal in regard to the subject and we knew now some of the things which we ought to have done but which we had not done, and some of the things we had better not have done which they would avoid in the future. Probably the ideal system of public lighting would be one in which all the streets were illuminated to an equal degree ; that would be a Mecca with regard to public lighting, but it was entirely out of the question—mainly on the ground of expense. The next best thing was to avoid contrasts between one street and another by, as Mr. Gaster had pointed out, grading the illumination between the two. Attempts had been made to do that in certain ways. For instance, in the case of an important thoroughfare having rather high power lamps and a high order of illumination, the lamps were put at crossings, so that the light went down the side streets as well as the main streets. In that way there was a gradual transition from the high illumination of the high candlepower to the lower illumination of the low candlepower lamps. That had been done to some extent in London, but there was a good deal of room for improvement to avoid annoying and undesirable contrasts.

Shop lighting would always be a difficulty in regard to public lighting. No doubt shopkeepers would have their lights on to the same extent that they did before the war if they got the chance, but something ought to be done to divorce shop lighting from street lighting by compelling the adoption of lamps which would illuminate the shop well and not throw the light out on to the thoroughfare, so that when the shops were closed the thoroughfare would not appear appreciably less illuminated. There were well-known opaque reflectors which directed the light into the shop and left the footway relatively unilluminated so far as the shop lamps were concerned. That was a point which was well worth consideration, and he was glad it had been raised in the paper.

The question of the uniformity of illumination along a street had been often discussed and quite a variety of opinions existed, but he thought that if there was one thing the illuminating engineer had learned more than another it was that lighting was a psychological matter which had influences which were very subtle and which could not be explained by photometric tests or any commonsense explanations. Some years ago some experiments were conducted by a Mr. Burtt, of Harvard University. This gentleman carried out a large number of experiments having in view the street lighting requirements of the tramcar driver and practically every other user of the street, particularly in regard to fast moving vehicles, and he came unquestionably to the conclusion that anything approaching uniformity was most undesirable, and that, as Mr. Goodenough had pointed out, provided the minimum illumination was sufficient, contrast was of very much less importance. The report of Mr. Burtt was an interesting one, and his researches certainly did not point in favour of uniformity of illumination in street lighting. It was a question of monotony versus mental stimulus, and Mr. Burtt came unquestionably to the conclusion that for high speed traffic, provided the minimum was sufficient, a certain amount of variation between the maximum and the minimum was very desirable indeed.

With regard to the lighting of architecture, Mr. Goodenough had mentioned that it was really out of the question on account of cost. It was a pity that was so because he thought London might be brightened up a good deal by the illumination of some of the structures. There were some, it was true, which were better not seen, but there were a great number which he thought could be seen with advantage. It would be nice to see them at night when they were not ordinarily visible. Some eight or nine years ago he discussed this matter, but it was not received with very much favour, but he had always felt that public buildings in London—and there were a number of beautiful ones—might very well be illuminated by some system of lighting such as that which was very extensively adopted in America and commonly known as the "flood lighting" system.

Mr. C. E. GREENSLADE said that coming from a district in which there had been no restrictions on lighting, one of the things which had been impressed upon him was the absence of glare which was effected by the obscuring of the globes. The result to him had been perfectly charming. He had never felt so much at home in London before. At the same time, if the light by this means was reduced below a certain minimum it caused a considerable amount of trouble to pedestrians. A matter which had an influence upon street lighting effects, both from the point of view of the pedestrian and traffic, was the nature of the roadway. With wood paving it seemed desirable to have a good illumination on the road surface on account of the nasty habit which wood paving had of coming up in bumps. On the other hand, a road surface of asphalt, precautions should be taken to prevent reflection from the surface. That had been very noticeable since the advent of motor traction, which had a polishing effect, and resulted in reflection of the street lighting from the surface of the roadway, which became very trying. He would like to see attempts made to prevent any direct light at anything less than an angle of 45°, which meant spacing the lamps rather close together and putting them rather high. Another point which had been exemplified during the war was the advantage of getting a steady light. Usually, where the streets were very wide they were lighted by lamps—originally arc lamps—placed very high up. During the war, owing to difficulties of labour and in obtaining carbons, these arc lamps had been replaced by the gas-filled lamp of a nominal lower candle-power, and these had given very much greater satisfaction to the general public, chiefly due, he was convinced, to the angle of lighting. One point had come out in that connection, and that was that in a street where the buildings were high, say 60 ft., and the lamps were placed at a height of 20 ft., the reflector above the lamp cut off the light almost with a straight line, which produced a very uninteresting effect from the psychological point of view. That required to be carefully borne in mind. Certainly the war had emphasised the disadvantages of reduced lighting, and he did not think anyone would like to go back to that. One aspect of lighting not mentioned was that it was the common idea that the lighting of side streets was to enable the police to do their duty effectively, but to his mind the chief idea undoubtedly should be to enable drivers of vehicles to see a certain distance ahead, according to the speed of the vehicle and on the speed on which the control could be worked. In the case of the driver of the big railway lorries, horse-drawn, who sat rather high up, the glare effect from centre lighting was rather trying.

Mr. H. A. CARTER said that the amount of light to be allotted to buildings required very careful consideration, and also the cost of lighting in relation to the building or structure. In particular, the nature of the reflecting surface needed to be studied. Dull surfaces absorbed a great deal of light, and were extremely difficult to illuminate properly. Some time ago he had worked out the lighting of some Government Ordnance Dumps. In the first place, corrugated iron sheds, painted a dark colour, were put up, and it was found necessary to use 500 watt lamps with appropriate spacing. Extensions to the sheds were made in reinforced concrete, and with the same spacing the same illumination was obtained with 300 watt lamps. There was thus a saving of 40 per cent. in the cost of lighting, due simply to the lighted tint of the reflecting surface.

Mr. J. N. STEPHENS said that whilst during the war other forms of lighting, and particularly industrial lighting, had received a considerable amount of attention, the important problems in connection with street lighting on a scientific basis had been neglected. There was now a great opportunity for seriously taking the matter in hand and trying to get some co-ordination if it was possible. There were now available correctly designed modern appliances which did not exist five years ago, but one point which made it difficult to improve street lighting conditions was the various types of permanent ornamental fittings in existence. Whilst during the last ten or fifteen years illuminants and systems of lighting had changed, the lamps were always hung on the same old fittings. He thought we should try and get rid of the ornamental posts and brackets and favour something more simple and flexible which will adapt itself to change in illuminant. In London, especially, they were largely tied down to the use of the old ornamental posts of varying heights and spacings, although these had been got away from in the case of the centre lighting in certain thoroughfares. He doubted if they would ever get perfect co-ordination between the various municipalities and the supply authorities on this question, and was of the opinion they would have to rely upon an educative campaign by the Society, illuminating engineers and manufacturers of street lighting equipment. He considered that a very great improvement in street lighting would be effected in the course of the next few years.

The CHAIRMAN, referring to the point made by the last speaker as to using the old-fashioned standards for modern methods of illumination, said that Westminster, when they improved their street lighting ten years ago, put up a lot of new columns at different heights according to the importance of the streets. They also re-arranged and took up and re-positioned a lot of the existing street columns. When they got a really progressive local authority like Westminster, they did not allow themselves, when progress took place, to be bound entirely by the physical conditions that existed. Westminster showed a great deal of progress and enterprise in the improvements they introduced, and so did the City of London when they revised their lighting. He proposed a hearty vote of thanks to Mr. Gaster.

Mr. W. C. CLINTON, in seconding, said he was not an expert in street lighting, but there was one thing, and that was the question of deciding definitely what was the maximum brightness that we were to be allowed to look at. That was one of the things that ought to be settled.

Mr. HAYDN T. HARRISON (*communicated*) : I regret that I was unfortunately unable to be present at Mr. Gaster's valuable introduction to the discussion on street lighting reconstruction problems. There is little doubt that the effect of the war has been to delay advance in this direction, but as Mr. Gaster points out, this may have compensating advantages, inasmuch as the London

INDEX, August, 1919.

PAGE
Editorial. L. GASTER 201

Illuminating Engineering Society—

(Founded in London, 1909)

ACCOUNT OF ANNUAL MEETING 205
NEW MEMBERS 205
REPORT OF COUNCIL for the Session Nov. 1918—June 1919 207
LIST OF JOINT COMMITTEES 218
LIST OF OFFICERS AND MEMBERS OF COUNCIL 220
LIST OF PAPERS READ (1909—1919) 221
Obituary—Professor A. G. VERNON HARCOURT 214
STREET LIGHTING RECONSTRUCTION PROBLEMS. By L. GASTER .. 225
Discussion—F. W. GOODENOUGH (*Chairman*), J. G. CLARK, C. E. GREENSLADE, H. A. CARTER, J. N. STEPHENS, W. C. CLINTON, HAYDN T. HARRISON, L. GASTER (*in reply*)
WORK OF THE ILLUMINATING ENGINEERING SOCIETY, THE 215

"Safety First" Council was able to put forward certain recommendations which should receive careful consideration from those who advise the local authorities who at present have the control of public lighting.

The suggestion of the formation of an Advisory Committee to take concerted action is one which should receive most careful consideration; if such a Committee could be formed with powers to enforce its recommendations no doubt good would result, but the difficulty would be in obtaining such powers while the present system exists of paying public lighting costs out of the local rates.

In the writer's opinion the public lighting of a complex district such as the County of London is one which should be dealt with and paid for out of a joint rate, in order to do away with such anomalies as poor lighting in poor districts and extravagant lighting in wealthy districts. The fact that a district is occupied by poor people is often the excuse for poor lighting; thus those people who spend more of their life in the streets than those in wealthy districts, and whose children are allowed to play in the gutter, are subjected to considerable risks. Moreover, the poor illumination impedes supervision in the streets, and interferes with the detection of disorder and even crime, which would be impossible in well-lighted streets.

Another great disadvantage of this unequal lighting is that the evening traffic is directed for safety's sake into the better lighted thoroughfares, thus causing an uneven distribution of traffic which results in certain roads being under repair at frequent intervals.

If a Central Board could handle both the traffic and the lighting problem, certain regulations could be enforced which would not only result in deviating much of the traffic to the less frequented roads, but would also brighten the lives of many whose existence appears to be forgotten.

The co-ordination of public and external private lighting is a solution of the whole problem which I have often advocated, not with the object of throwing the onus of public lighting on to private shoulders, but to make arrangements by which public lamps may be attached to private property, and thus do away with street obstructions, make it possible to considerably increase the number of light sconces and bring the same out of the line of sight. It is unnecessary to go into the great increased efficiency of such a system, which would take advantage of the natural distribution of light over a circular area, and not over an elongated area as is presented by a street.

The saving in first cost, convenience of maintenance, of light sconces erected on buildings alone would be sufficient to allow financial compensation to be paid to private owners, but unless compulsory powers to erect such lights are granted the whole advantage of such a lighting system is liable to be frustrated by the obstinacy of individual private owners.

Mr. Gaster again emphasises the importance of the reduction of glare. Unfortunately glare is often the result of attempting to improve distant illumination. Thus if the distance apart of lighting units is not reduced glare frequently results with improved illumination. Diffusing appliances naturally lessen glare, but they also reduce distant illumination, therefore if minimum illumination is to be the standard to be improved, glare will probably result unless the lighting units are placed at close intervals.

If the number of units cannot be increased and glare is unavoidable, the only solution appears to be the elevation of such units to a height where they are out of the line of sight. Such a height is often unpractical on posts and the height can only be attained by fixing to private property. I would, therefore, advocate that every effort be used to obtain powers to enforce private owners to allow of such fixtures, and would suggest that this be dealt with as one of the most important of Reconstruction problems.

Mr. LEON GASTER, in replying to various points raised in the discussion, said that he quite recognised the complexity of the problem of securing uniform treatment of the lighting of London. He had merely thrown out some tentative suggestions, but what he was anxious to secure was that all the various aspects of the subject should be considered together, and not in separate compartments. The question of motor-car headlight regulations, for example, ought really to be considered in conjunction with street lighting, and the latter, as he had shown, was directly associated with the guidance of traffic. It ought, therefore, to be possible to secure joint consideration for all such problems.

He thought that there was general agreement that it was in principle desirable to obtain uniform illumination in streets, but he agreed with Mr. Goodenough that if the illumination was fairly high the effect on the eye of variations in illumination was less than in streets where the general value of illumination was very low. It was chiefly in the latter cases that lack of uniformity in illumination-values was objectionable, and unfortunately a very large proportion of streets would fall within this category. It was also most important, if uniform illumination could not be provided, that the transition from high to relatively low values of illumination should be gradual.

In regard to shading, he considered that at present not enough was done to diminish the intrinsic brightness of sources, though he agreed that unshaded lights were less troublesome when placed at a high level. He did not think that the allocation of an appropriate illumination for lighting the exteriors of buildings inevitably involved undue expense. Naturally judgment was necessary in selecting the buildings, monuments, and objects to be illuminated, but in many cases the gain in diffusion, and the raising of the general level of brightness, would be well worth while, as it diminished the severe contrast between street-lamps and the surroundings. Mr. Clinton had pointed out the need for a standard of brilliancy, but he thought that this would have to be considered in relation to this matter of contrast—a point to which Mr. Harrison's written communication also refers. He was also glad to have Mr. Clark's confirmation of the desirability of avoiding excessive contrasts in passing from one street to another.

In regard to shop-lighting, it was true that in general this was only available during certain hours, but even so there was no reason why the lighting should not be so devised as to be helpful to traffic while it *was* in use. He presumed that in the future, when the present shortage in fuel and the need for severe economy had passed away, the pre-war practice adopted by some firms of leaving shop-windows illuminated after business hours, as an advertisement, might be revived. Mr. Harrison had also expressed agreement with the suggestion that more might be done to correlate public and private lighting, and he believed that by suitable encouragement a great deal of assistance to public lighting could often be obtained from private consumers.

·ELECTRICITY· The ·ACETYLENE·
ILLUMINATING
ENGINEER
·OIL· Edited by ·GAS·
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

Diffused Reflexion and Transmission of Light.

The special article which Mr. A. P. Trotter contributes to this issue on the above subject raises points of great scientific interest. The nature of the reflexion of light from rough and smooth surfaces was examined in great detail by Lambert, Bouguer, and others, of whose work Mr. Trotter gives a summary. Investigations of the present day would profit from a study of these early researches. The exact nature of the so-called diffused reflexion from rough surfaces demands further investigation. Various problems depend upon the understanding of such phenomena—for example, the development of an ideal white and completely diffusing standard surface, such as would be of great value in photometry and as a standard in researches on colour. Mr. Trotter describes his experience with Bristol board, white celulloid, etc., and the method of procuring an approximately matt surface in each case. These materials have done good service in photometry, but it would be a great advantage if agreement could be reached on a suitable standard white material, preferably one whose surface cannot readily be impaired by careless usage. Compressed plaster of Paris, magnesia and similar substances have been suggested and favourable results can be obtained by these methods if they are used with care. However, the mode in which pressure is applied appears to be of importance and in general such surfaces can be too readily scratched, cracked, or rendered shiny by a sliding pressure. It has been suggested that a good white porcelain with matt surface would repay investigation. The study of such surface has also a direct bearing on materials for the interior of reflectors, many of which, like white enamelled iron, reveal a combination of diffused and polished reflexion. In such circumstances the calculation of the contour to give any desired distribution of light is a matter of some complexity.

In all cases where one is dealing with more or less shiny surfaces there are two distinct points to be considered: the effect of the surface itself in supplementing diffused or scattered reflexion by regular or polished reflexion; and the effect of the angle at which the light strikes the surface as a whole. Similarly, in the second section of Mr. Trotter's article, dealing with the transmission of light through scattering materials, both the variety of the diffusing medium and the direction of the incident light are of importance. In either case the nature of the distribution of the light can be conveniently represented by polar curves which would assume a perfectly circular form if complete diffusion were obtained. It may be noted in passing that Lambert's Law (the " cosine law ") merely relates the *illumination* to the angle at which the incident light is received. It has thus nothing to do with the nature of reflexion by the surface and, strictly speaking, it is incorrect to say that a completely diffusing surface " obeys Lambert's law." The method of treatment by means of polar diagrams suggests a possible definition of " diffusion " in regard to surfaces, a term which at present is apt to be somewhat loosely used.

The phenomena occurring when light is transmitted through diffusing media, such as etched, ground or opal glass, likewise require further explanation. Mr. Trotter remarks that the treatment of the scattering effect of particles in suspension might almost form a special section in optics. The problem of chief interest to lighting experts is the behaviour of so-called diffusing glass. It is well known that the effect of light passing through such media may be very different according to the nature of the glass, surprising variations being found even in types of glass which appear to the eye substantially similar. White or opal glasses notoriously differ greatly in this respect. In some globes the source itself is invisible and the entire surface appears evenly illuminated; in others one sees the source dimly surrounded by a halo of light; in others, again, the globe may appear of even brightness, but the source is faintly revealed with a reddish tinge. The whole question of the effect on light of scattered particles in suspension, whether in glass, air or water, requires elucidation. Such scientific researches as Mr. Trotter describes are the necessary preliminary to an understanding of the nature of diffusing glasses and the preparation of a definite specification of quality. During the war the quality of opal glass available has been notoriously irregular. In the future we look for much greater precision in this respect. Of special consequence is the question of absorption. Apparently insignificant variations in the method of manufacturing these diffusing glasses may give rise to considerable differences in the amount of light absorbed. Mr. Trotter has furnished a comprehensive summary of investigations to date on the diffusion of light by surfaces, including his own researches which are not yet completed. There is obviously room for a great deal of further experiment. We commend the matter to the notice of research workers, in particular those connected with illuminating engineering glassware, such as the members of the Society of Glass Technology, with whom the Illuminating Engineering Society has already conferred on this subject.

The Transmission of Coloured Light Through Fog.

In studying the effect of fog on the beams of searchlight or ordinary illuminants we have again a problem involving the scattering of light by particles. The so-called "penetrating power" of various illuminants has long been a matter of dispute. A prolonged controversy on the relative merits of oil and electric arc lamps for lighthouse work, terminating in the appointment of a Royal Commission to study the subject in 1890, revealed great difference of opinion on this subject. Advocates of the oil lamp contended that in spite of its lower illuminating value its greater penetrating power made it more valuable for lighthouse work than the much more powerful arc lamp, but this contention was not fully maintained. Similar discussion has raged around the question of the relative value of gas and electric arc street lamps in a fog. The fundamental problem of the effect of colour on the transmission of light through a foggy atmosphere has been somewhat obscured by other physiological considerations, such as the effect of the size of the source on visibility, and the power of the eye to distinguish distant coloured lights. So far as absorption of light is concerned the balance of opinion seems to lean to the view that rays from the red and yellow end of the spectrum penetrate the atmosphere better than those in the green, blue and violet. This is supported by the well known golden appearance of the rays of the sun at sunset and sunrise, and by the classical experiments of Professor Langley, showing how the maximum in the spectrum of solar radiation shifts towards the blue as the altitude of the point of observation rises, so that on a mountain summit the nature of the radiation is markedly more blue than at sea-level. Broader generalisations have also been drawn from a comparison between wireless waves (merely electromagnetic waves of great wave length) which pass by solid objects with ease, and ultraviolet rays of very short wavelength which are rapidly absorbed even by a short length of atmosphere.

All such generalisations, however, require to be supported by exact tests, and an interesting attempt in this direction by Mr. C. L. Utterback was recently recorded in the transactions of the American Illuminating Engineering Society. A summary of this research is given in this issue (pp. 269-270). Experiments were made on a form of artificial fog, enclosed in a tube and adapted to a careful study of the transmission of coloured light. The conclusion is reached that the maximum transmission was attained in the yellow (5300—5900 $\mu\mu$). It is somewhat surprising to find that the transmission in the extreme red, as well as in the blue and violet, was less than in this central region. It is probable, as was suggested, that much depends on the nature of the fog; that the absorption of light by water vapour may be a different problem from the loss of light through the scattering effect of suspended particles. One may therefore expect differences in the behaviour of fogs and mists in different localities; a sea-mist, for example, may be different from a city fog, which is commonly coloured by suspended impurities. We are therefore glad to note that these results on artificial fog are to be supplemented by observations on various forms of natural fog and mist. We shall await further results with interest. The matter is one that has an obvious bearing on the use of searchlights and of lighthouses, beacons and flares used for navigation, and is likely to assume special importance in connection with the future lighting of the "highways of the air" as an aid to aerial navigation.

Good Lighting as an Element in Safety.

We notice that an important exhibition has been arranged by the National Safety Council in the United States, to take place in Cleveland, on October 1st—4th, in conjunction with the eighth annual congress of this body. It is stated that a great effort will be made to display all the latest safety devices and that 350,000 cards of admission will be distributed amongst the delegates to the congress and workmen at factories in the vicinity. A feature of great interest in this exhibition is the demonstration of factory lighting, arranged by the National Lamp Works, and filling the entire stage of the Grays' Armoury, in which the display is to be held. A shop is to be shown in operation with three alternative systems of lighting, one illustrating poor illumination, one medium conditions, and one an ideal lighting installation from the safety standpoint. The systems will be switched on alternately, and explanations of the defects and merits illustrated will be given. There are demonstrations of model lighting for offices and draughtsmen.

We draw attention to this important demonstration because we have here yet another instance in which a useful idea conceived in this country has been unavoidably prevented from coming to fruition owing to the war. When the Industrial Museum was planned in London immediately before the war, we understood that it was resolved not only to illustrate all the latest safety appliances, but to include amongst the exhibits demonstrations of various systems of lighting, illustrating their proper application in factories from the safety standpoint. The erection of the building for the museum was completed early in 1914, and its equipment was about to be proceeded with. Owing to the emergency of the war it was necessary for this, in common with many other buildings of importance, to be converted to other uses, but its position is well suited to its original purpose. We understand that, even when this museum was being erected, the prospective exhibits were already so comprehensive as to more than fill the allotted space, and that the authorities therefore wisely selected a site with possibilities of further extension, and in the subsequent period there have doubtless been many other advances in safety appliances which might well be exhibited. Considering the distractions of the war the "Safety First" campaign in this country has made excellent progress. The London "Safety First" Council has already done good work towards the diminution of accidents in streets, and its off-shoot, the British Industrial "Safety First" Association, will doubtless do a similar service in the industrial field. Our losses in the war should teach us to take every possible measure to counteract the continuous drain involved in accidents in factories and workshops, and the present moment seems most opportune for pressing this work of reconstruction. We hope, therefore, that it will not be long before this country is in possession of the Industrial Museum, fulfilling the same functions as the corresponding well-equipped institutions in several other countries. It will thus be possible to demonstrate, by actual examples and model equipment, the value of the efforts which are being made to reduce the number of accidents by the use of safety methods and appliances, among which the provision of adequate industrial lighting forms an important element.

LEON GASTER.

DIFFUSED REFLEXION AND TRANSMISSION OF LIGHT.

AN UNFINISHED RESEARCH.

By A. P. Trotter.

SUMMARY.

Part I. Diffused reflexion. Lambert's account of regular and of scattered reflexion, and the well-known Lambert's law of illumination, together with his observations on brightness of unpolished surfaces are given in literal translation from Photometria, *published in Latin in* 1760. *Bouguer's experiments, illustrated by polar curves and reference to his hypothesis of scattered reflexion, are translated from the French, published in* 1729. *The investigations of Lommel, Blondel, Christian Wiener, and H. R. Wright are summarised and discussed.*

The author's work, begun in 1891 *and suspended in* 1914, *is described. It is shown how specular reflexion can be separated from diffused reflexion by drawing an internal osculating circle, instead of the circumscribing circle of Bouguer and Blondel, and how, when rectangular co-ordinates are used instead of polar, diffused reflexion is represented by a curve in some cases closely representing the probability curve or curve of frequencies, and it is suggested that there is a rational connection with the statistical function.*

The author's apparatus is described and numerous examples of his results are given. He incidentally found that the brightness of a matt surface varies with the angle of aspect or emission.

Part II. Diffused transmission. Starting in 1883 *from an investigation of the difference in scattering of light by the grease spot and by the paper of a Bunsen screen, many experiments were made with various materials. Graphical analysis as used in Part I. yielded curves closely resembling the curve of frequency or probability. His intention was to study various kinds of opal glass, and so to classify and describe their optical characteristics, but the research remains unfinished.*

INTRODUCTION.

CATOPTRICS and dioptrics, those branches of optics which relate to the reflexion and refraction of light, are considered primarily, as a rule, with reference to the action of polished bodies and of transparent media respectively, and elementary treatment generally neglects the secondary considerations of the scattering of light due to imperfect polish of a reflector, or to turbidity of a refracting medium. The absorptions and losses are of a selective nature and may accompany the highest polish and transparency. The scatterings by imperfect polish and by turbidity are homologous, and almost deserve the constitution of a branch of optics for their consideration. This subject has numerous practical applications.

Bouguer, whose *Essai d'Optique* was published in 1729, and whose *Traité d'Optique* was published in 1760, two years after his death, and Lambert, whose *Photometria*, written in Latin, was published in 1760, wrote on these secondary considerations, and their contributions to knowledge are, to a large extent, complementary to each other. None of these works have been translated into English.

The mode of scattering can be clearly expressed graphically, and if any analytical equations can be found to define the law or laws of scattering, they may be deduced from the curves obtained by experiment.

If a reflecting surface, perfectly matt, that is, devoid of any polish, or a translucent material of the type of opal glass scatters light uniformly in all directions, it may be shown that the polar diagram of the luminous intensity or candlepower would be a circle, and the cartesian diagram a cosine curve. The brightness diagram would be a semi-circle with polar, and a straight line with rectangular co-ordinates.

PART I.—DIFFUSED REFLEXION.

Lambert (*Photometria*, Part III., Cap. I., § 623) makes the following admirably complete statement about reflexion: " The first part, or all the light which is reflected following the direction CR (Fig. 1), and which therefore is due to the surface A B, so far as this is polished and smoothed, we shall call reflected light, and on this depends all those matters that are demonstrated in catoptrics by the reflexion of light. The second part, which depends on the roughness of the surface and on heterogeneous particles, we shall speak of as dispersed light, since, indeed, it is scattered in all directions. The third, which emerges again from the lamina A B b a and spreads in every direction, and determines that the body is seen in its colour, we shall call issuing (*emanans*) or coloured light. To these finally a fourth may be added, of which all that light is included which is dispersed in the substance itself, and of which the quantity is very considerable; in most cases it far exceeds the sum of the other three parts. This, therefore, since it is absorbed by the substance, we will call lost (*amissum*) light. The first three parts are very often confounded together."

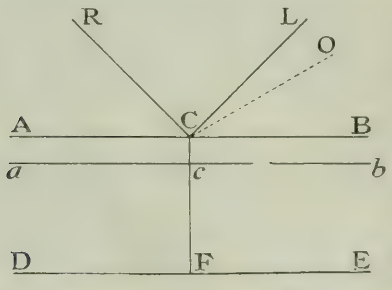


FIG. 1.—Lambert's diagram of reflexion.

Lambert's name is well known to students of optics for his so-called, and often misunderstood, " law." This is an extension of the last of the three " primary notions of photometric science " :—§ 46 " (1) Two or more candles give more light than one. (2) An object moved nearer to a light becomes brighter (*clarius*). (3) Light falling obliquely on a surface illuminates it less." The first enunciation of this law is found in § 53 : " The normal illumination will be to the oblique illumination as the whole sine is to the sine of the angle of incidence. Early writers took the angle of incidence as the angle between the plane of a surface and a ray incident on it. We now take the angle between the ray and the normal to the plane, and Lambert's law becomes a law of cosines. So far as illumination received on a plane is concerned this is an obvious deduction from his consideration of the " density of radiation." Lambert's law therefore relates to the illumination received and to the angle of incidence.

When it is sometimes stated that no unpolished or matt substances " perfectly obey Lambert's law," the intention is to suggest that if the surface were devoid of any polish, and if all specular reflexion were therefore absent, the light reflected in any direction would vary as the projected or apparent area of the substance as seen from that direction; in other words, as the cosine of the angle with the normal. Where the cosine function is under consideration, Lambert is frequently dragged in.* The polar distribution of the light from the positive pole of an electric arc is often stated to depend on Lambert's law.

Part I. of Lambert's *Photometria* deals with elementary principles ; Part II. with direct light and its measurements ; Part III. mainly with the establishment of the principles, or as they are afterwards called, laws, of photometric science. The " primary notions " are now expanded as follows: "1°. That the illumination is greater in proportion to the number of candles or of lights or of radiant points by which a sheet of paper or a plane exposed to these is lighted up. II°. That the same is smaller by so much as the square of the distance from the illuminated plane to the luminous body is greater. III°. That it decreases in the ratio of the sine of the angle of incidence." Passing over Part II., which deals with dioptrics, Part III. discusses the action of opaque bodies on light. Chapter I. treats of polished mirrors, and Chapter II. with the brightness of an illuminated object and the brightness of an opaque body which is lighted up by it, and whose surface is more or less rough or unpolished.

---

* Chwolson. *Phys. French Trans.*, Vol. II., pp. 37 and 39, on Lambert.

Lambert observes at the beginning of this chapter :—

"The brightness (*claritas*) of a light or of a luminous object and the brightness of an opaque body illuminated by it, whose surface is more or less rough or unpolished (*minusque polita*), are compared by experiments.

"§ 696. We have already seen in the beginning of the previous chapter (§ 622, 623) that the light falling on the surfaces of opaque bodies is divided by them in four ways, and is to be calculated accordingly, and we have given an exposition of that part of the light, which we have by way of distinction called reflected light, as to leave no want of material (for investigation) to those who may have the inclination and the leisure to determine this reflected light by observation for individual given bodies. To the three remaining parts, which we have left almost untouched, let us now return, and let us discern in what proportion the light scattered by opaque bodies is to be determined as coloured and lost.

"§ 697. Since the surfaces of all bodies may be so smoothed that when the roughness is taken away they appear more shining (*nitidiora*) and in part, at least, reflect light, it follows that reflected light is never wholly absent from them, but that it is so mixed with coloured and scattered light that it is given back in combination with this coloured and scattered light in all directions.

"§ 626. It is evident also that this happens as soon as the surface of a body is so roughened that all polish (*nitor*) is entirely removed, and the smallest particles on the surface reflect light in all directions at all angles of incidence. It is easily shown by experience that this is a property of bodies devoid of all polish, but if such a surface is subjected to a microscope, one can see at the very first glance that it presents a rough and uneven appearance like that of mountains and valleys.

"§ 698. When, moreover, such roughness is of the greatest irregularity it will scarcely be possible to bring these unevennesses under any particular law, by laying down which a computation can be made of light reflected in all directions. For, although as the celebrated Kaestner has pointed out, these unevennesses may rightly and properly be regarded as like exceedingly small mirrors, placed equally in all possible positions, yet it must be granted that there are small interstices through which the light can freely pass on its way to the interior parts of the body. And similarly it must be inferred that, because they are placed in every kind of position, some of these mirrors are necessarily shaded by others. Moreover, since all possible positions of these mirrors exist simultaneously, light falls on them simultaneously at all angles. The result is that the very greatest diversity of reflected light is produced, which cannot fail to make the computation most intricate."*

This conception by Lambert of a surface devoid of all polish was of great importance. Bouguer and later writers, failing to recognise purely scattering reflexion, have endeavoured to find a simple explanation of a mixed effect. Under modern conditions of photometric measurement such surfaces are not so common as Lambert suggests. In the second experiment described in this chapter he deals with the scattered light from a candle reflected from a white card: "Wherefore the direct illumination (of another card) will diminish as the sine of the angle under which the light issues." This is one of the rather rare cases in Lambert's *Photometria*, where a matt white surface is considered as a (secondary) source of light. It is noteworthy, since it justifies the application of Lambert's law to scattered reflexion.

---

* I am indebted to Dr. J. K. Fotheringham, of Oxford, for help in translating this passage.

"It will not be superfluous to confirm this new law of illuminating forces, which hitherto have been deduced from one solitary observation, by other observations also, among which the following is the one of most frequent occurrence. If we look from any side at a white wall illuminated either by the sun or by open daylight, the opening of the pupil remaining constant, the wall will in every instance appear white to our senses, and will be seen to be white with an equal degree of brightness; with this difference, however, that while in the former instance the wall, like an ordinary mirror, reflects certain rays, it sometimes seems brighter at that spot from which the reflected rays proceed. In the latter case this is different, since the illumination proceeds from half the hemisphere of the sky. The same thing will be seen if a plane white surface be placed in the open in such a way that it is illuminated by the whole hemisphere of the sky, when it is covered by clouds and whitish mists, or when it is illuminated just before sunrise or just after sunset. In these conditions you will see that that plane surface, from whatever side you look at it, is equally bright to our senses. When this is the case it will be shown, as above, that the illumination is as the sine of the angle of emanation."

This statement about equality of brightness "from whatever side you look at it" was probably based on general observation and not on measurement. It has been commonly accepted as part of Lambert's law, but he gave it no such prominence. Deviations which have been found from it must not, therefore, be treated as in nonconformity with Lambert's relation between illumination received and the angle of incidence.

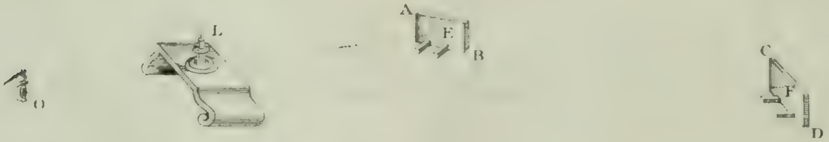


FIG. 2.—Bouguer's illustration of his method.

Before leaving Lambert's work reference must be made to his ideal of whiteness to which he gave the name *albedo*. A surface having an albedo of unity would be perfectly matt, and would scatter in all directions the whole of the light incident on it. Such a surface, of an area of π square feet receiving an illumination of one foot-candle, or an area of one square foot receiving an illumination of π foot-candles would reflect one candle-power normally, and have a hemispherical candlepower of one-half candle. Albedo is, therefore, also the ideal or maximum of diffused reflecting power.

The Third Section of Book II. of Bouguer's *Traité d'Optique* is "On the Reflexion of light from matt (*mattes*) or rough (*brutes*) surfaces." He attacked the subject experimentally, and tried to find a hypothesis to account for the results obtained. His first one was to assume that the surface is covered with small polished hemispheres, but calculation showed that this would not explain the matter. He then had recourse to other shapes, and conceived that the "surfaces have numerous little wrinkles (*rugosites*) or roughnesses (*asperites*) which, presenting many of their facets on every side, reflect light in all directions. The rays which are lost from one observer become useful for another who is placed in another situation."

Bouguer's experiments consisted in illuminating two similar surfaces by a candle or lamp, moving one at different distances from the source of light, but keeping it always perpendicularly exposed. (Fig. 2.) The other was kept always at the same distance, but was inclined at various angles.* The apparent brightness of the two surfaces was adjusted to be identical, as seen from the direction in which they were lighted. He plotted the inverse squares of these distances as polar curves (Fig. 3).

---

* Bouguer used the old notation, measuring angles with the surface, not with the normal to the surface.

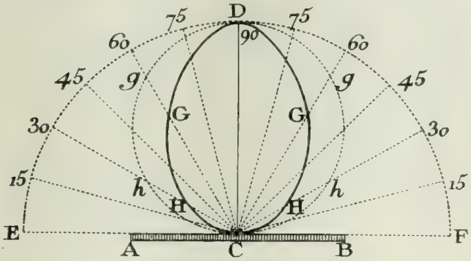


FIG. 3.—Bouguer's "numeratrix" curve.

"The similarly-inclined facets are distributed uniformly over the whole rough surface . . . we express them all together by the lines CD CG which are perpendicular to them, and these lines are the ordinates of our curve to which we might give the name of Numeratrix of Roughness. This curve almost always takes the form of a kind of oval, higher than it is broad, and the lower part of which usually ends in a point. . . . This oval is in reality appreciably sharper at the top than at the bottom in the case of plaster, and its width is only about 11-20 of its axis CD. In the case of Dutch paper the width of the oval is about two-thirds of the length of the major axis. If our curve, the numeratrix of roughness, had exactly the form of a circle such as ChDh, the rough surfaces would have a very singular property, even when illuminated very obliquely; provided they were looked at by the spectator at the same angle and from the same side."

We now know that there is nothing singular in this, it is the property of any perfectly matt surface, and the provision mentioned is not necessary. It is the property of a surface completely obeying the cosine law, or, as it is commonly called, Lambert's law.

The reference to the lower part, which usually ends in a point, is difficult to understand, and we need not follow Bouguer in his discussion on the number of facets which act as various angles, nor his treatment of his results before plotting his curve. His precision was not great, and the radii may be considered simply to be proportional to the observed brightness at each angle. He was attempting to find an explanation of the curve as a whole, and had not recognised the different modes of reflexion enumerated by Lambert. His experiments appear to have been made only under the condition that the incident light was as nearly as possible in the direction of the line of sight, but in his theoretical discussion he considers other cases.

I propose to give a short account in historical sequence of the investigations of Lommel, Blondel, Christian Wiener, H. R. Wright and Nutting; to give my explanation of the difficulties which presented themselves; to apply my explanation to the results of these writers, and finally to give some of the results of my own experiments.

E. Lommel, in a paper on Fluorescence,* tried to account for what he imagined was Lambert's law by introducing the idea of a "volume element," in fact Lambert's "third part," where the light penetrates somewhat into the body and emerges again. Lommel gave three propositions "which were to be taken as a basis for the theoretical treatment of photometric problems." In each of these the "volume element" made its appearance. He stated as his third proposition that "the light radiated by a volume element is enfeebled on its way through the radiating body according to the law of absorption." This is true enough, but in a paper by the same author on the Photometry of Diffused Reflexion† nine years later, he quoted these propositions and made the obscure statement that "Lambert's law of the cosine of the angle of emission was thus eliminated from the set of photometric principles, and its place was taken by the present proposition 3." He went on to state, "For diffusively reflecting bodies, the cosine law had, since Lambert, been taken as determining the intensity of light reflected by them. This assumption could, however, neither be based on theory, nor did it appear to correspond with the facts of observation." He then referred to Seeliger, who showed that in the case of the photometry of planets "Lambert's law for diffusing bodies cannot be thought of." This, again, merely shows a misunderstanding of the law. Bouguer considered that a different law must be applied in the case of the moon and planets, and his way of expressing it was that the numeratrix curve would lie outside the circle instead of within it. This is an interesting subject, but cannot be discussed on this occasion.

---

* *Wied. Ann.*, Vol. X., pp. 449–631, 1880.

† *Wied. Ann.*, Vol. XXXVI., p. 473, 1889. Abstracted in the *Electrician*, Vol. XXXIII., p. 691.

Later on in this article Lommel, assuming an absolutely white body, dismissed all the difficulties which he had raised, and made the two following propositions: "If an absolutely white body is illuminated by parallel rays from any direction, the amount of light sent out in all directions from its surface (the illuminating power) is proportional to the cosine of the angle of incidence." If the surface of an absolutely white body is equally illuminated from all directions, the quantity of light radiated by it in any direction is proportional to the cosine of the angle of emergence. These two propositions show in what sense and with what reservations the cosine law for the angles of incidence and emergence respectively may be taken as valid.

Lommel's difficulty was the same as Bouguer's. It is like an experimental investigation of the trajectory of a projectile. Gravitation and air resistance result in a curve which differs materially from a parabola. But we should not for this reason say that Newton's laws must be eliminated, and that they do not correspond with the facts of observation.

Lommel gave a complicated formula, and claims that experimental results with paper, cardboard and porcelain agree better with his new law than with Lambert's. These two papers contribute nothing of any importance except the two propositions which have been quoted, and the first one is not true.

While I was working on this investigation in 1891 I found that, as has happened on more than one occasion, my friend Prof. A. Blondel was independently studying the same question in Paris, and some correspondence passed between us on the subject in that year. Prof. Blondel was working on the construction of apparatus for determining the mean spherical intensity of sources of light, and wished to make a conical reflector giving truly diffuse reflexion. His work on this subject was published in *L'Eclairage Electrique** and in 1895 appeared as a small book.

A diagram of his method of investigating diffuse reflexion is reproduced in Fig. 4. A B is the plate to be studied, L a movable lamp with a lens furnishing the incident beam, P the fixed photometer. There was no standard screen as in the experiments of Bouguer, Wiener and myself, but the actual light reflected was measured. Fig. 5 gives his result for depolished opal glass viewed at 30° with the normal, and Fig. 6 for enamelled sheet iron viewed at 35°. He tried paper, cardboard, matt marble and biscuit porcelain, which nearly followed Lambert's law. He at last hit on enamelled iron depolished with hydrofluoric acid. Fig. 7 shows the remarkable result obtained.

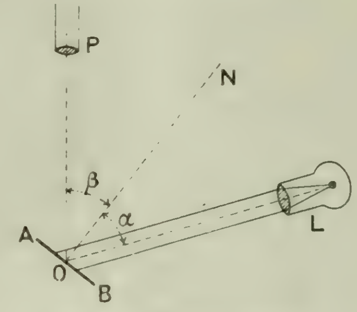


FIG. 4. Blondel's method.

Christian Wiener, in a paper on Diffusion of Light by Dull Surfaces† in 1892, gave references to Lambert and a good account of Bouguer's experiments and of the elementary part of his theory. He stated: "That Lambert's law is not generally true was already shown by Bouguer's observations."

---

* *La Lumière Electrique*, XXXV., p. 615.

† *Wied. Ann.*, Vol. XLVII., p. 638, 1892. Trans. the *Electrician*, Vol. XXXIII., p. 549.

His method was that of Bouguer so far as the use of a pair of plaster plates was concerned, "moving one until both plates appeared equally bright at their apparently coincident edges, so that their images coalesced." But, unlike Bouguer, he used two candles. "The two sources of light were screened in such a manner that each of them only illuminated one of the plates." This quite accounts for the want of precision of Wiener's experiments.

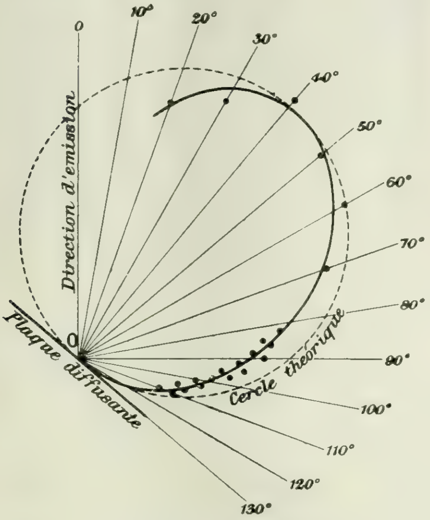


FIG. 5.—Blondel, depolished opal glass.

He worked chiefly with a fixed angle of incidence and varying angles of emission. This must be carefully distinguished from the investigations of Blondel and myself, in which the direction of view or the angle of emission is fixed for each experiment, and the angle of incidence varies. If Wiener's plaster surface had justified Lambert's observation that "the plane surface, from whatever side you look at it, is equally bright," the polar diagram would be a semi-circle, the equal radii representing equal brightness as seen from different directions, and the rectangular plotting would give a horizontal line.

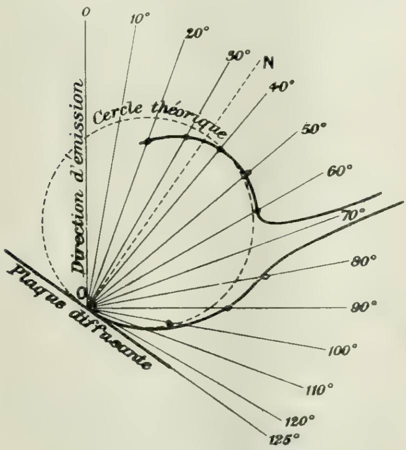


FIG. 6.—Blondel, enamelled sheet iron.

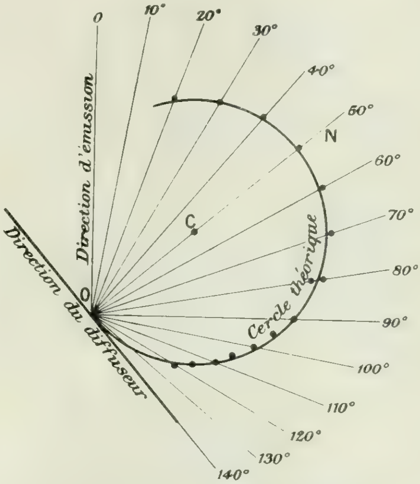


FIG. 7.—Blondel, depolished enamelled iron.

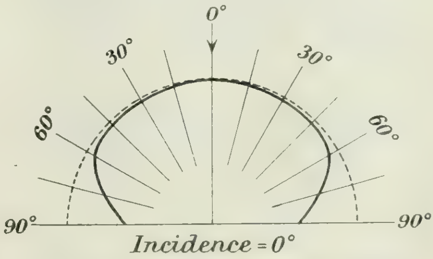


FIG. 8. C. Weiner, plaster of Paris.

Notwithstanding his want of precision, some of his results deserve attention. Figs. 8 to 11 are polar curves showing his results with incidence 0 deg., 30 deg., 60 deg., and 75 deg. Fig. 12 shows the same set of observations as Fig. 8, plotted with rectangular co-ordinates which enable the deviation from the horizontal line to be appreciated more clearly than the deviation from the semi-circle.

H. Wright* published a paper on this subject in 1900. He used fine powders, for convenience pressed into

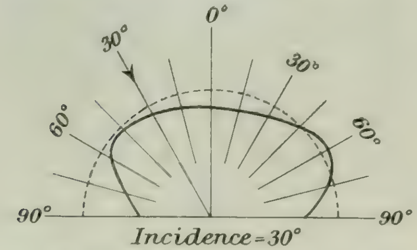


FIG. 9.—C. Weiner, plaster of Paris.

plates by a pressure of from 4 to 20 tons, which he states did not affect the optical result. But this I consider somewhat doubtful. Much depends on the surface against which the powders were pressed.

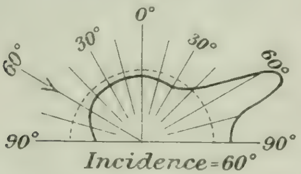


FIG. 10.—C. Weiner, plaster of Paris.

He also states that no polarisation was found. This may be neglected in ordinary photometry, but he used a polarisation photometer. His method is not easy to understand, as he gives only a reproduction of a photograph of the whole equipment of apparatus, and no diagrammatic representation of the arrangement. He employed an arc lamp of 500 candlepower, a standard comparison plate of the same substance as the one to be studied, and a Glan's polarising spectro-photometer. He took precautions to ensure not only that incident rays should be parallel, but that parallel reflected rays selected out of scattered light should alone reach the photometer. He stated, not, perhaps, as clearly as might be wished, the two different methods which may be employed, namely, the measurement of the reflected candlepower or the measurement of the brightness. He observes that Lambert elaborated his law by the observation of brightness. This is not so. Lambert deduced it from the most simple geometrical principles, and adduces his observation of the brightness of a sunlit wall as an example.

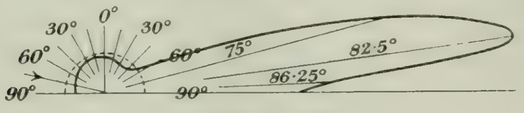


FIG. 11.—C. Weiner, plaster of Paris.

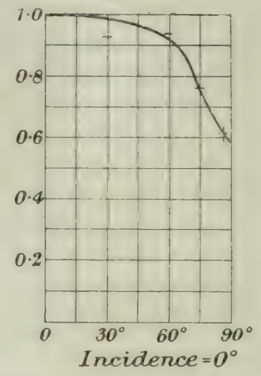


FIG. 12.—C. Weiner, plaster of Paris.

A rather perplexing statement is made before the results are given. "*The Compensation of the Measurements.*—The measured quantities are not the real objective-intensities of illumination; they are only functions of them, being the excitation produced on the eye. According to Fechner's psychophysical law, the intensity of the sensation is proportional to the logarithm of the excitation. Consequently these logarithms must be used for the compensation."* Wright's results with coloured powders and with coloured light on white substances do not concern us at present, and there remain, carbonate of magnesia, and plaster of paris with "mixed waves," probably the simple light from the arc. In the last of the tables in this paper the author appears to drop logarithms and to give deviations from the laws in percentages. For carbonate of magnesia the quantity which would have to be added to cos ι is 14·0 per cent., the quantity to be added to cos ε, 2·5 per cent., and for deviation from Lambert's law in totality, 10·1 per cent. He deduced that "the *law of cos ι is not valid*," but "the *law of cos ε is*, on the other hand, *perfectly correct*, whilst Lambert's law in totality naturally shows great deviations caused by the cos ι. Hence a law of illumination can never be symmetrical in reference to ι and ε." But Wright goes on to say that, "examining the results more closely one finds that the observations come nearer to the law of the cos ε the more matt the plates were, or, what is the same thing, the less normal reflexion they showed . . . It is clear that the plates must be really matt if one wishes to deduce a theory from observations on them."

---

* "Diffused Reflexion." *Phil. Mag.* XLIX., p. 209, 1900.

* Seeliger, *La Lumière Electrique*, XXV., 615, has published measurements of reflecting power of various substances, giving the results as logarithms. The object of this generally is to facilitate the comparison of ratios. There is no rational connection with Fechner's law.

In his *résumé* of results, omitting those relating to colour and to polarisation, he states, "(2) The intensity of the light diffusely reflected under the angles $+\varepsilon$ and $-\varepsilon$ is the same. (4) A law for the intensity of reflected scattered light cannot be symmetric in reference to ι and ε. (5) The intensity of the diffuse reflected light with the angle ε constant and with varying angles of incidence ι is not proportional to the cos ι as Lambert assumes. (6) The intensity of the diffuse reflected light with the angle ι constant and the angle ε varying is proportional to cos ε, or *Lambert's law of emanation is strictly correct for absolutely matt surfaces without any exception.* (7) The so-called law of the cosine ($q = \mathrm{I}'_2\ ds.\ \cos\iota\ \cos\varepsilon$) is not true in consequence of the deviations of the law of the cos ι. The deviations range between 4·6 per cent. and 10 per cent."

Nothing can be made of the numerical results in the strange way in which they are given, but taking their antilogs I have plotted them as polar curves, and get the results shown in Figs. 13 and 14. This is for plaster of paris "mixed waves." Except for three mistakes or misprints the antilogs of his observations with constant angle of incidence and varying angles of omission when plotted as polar curves lie very closely on circles which agrees with his result No. 6. But plotting his observations with the angle of emission constant and varying angles of incidence yields a family of elliptical curves having their major axes normal to the illuminated surface. If these major axes were inclined in each case at an angle equal and opposite to the angle of emission, they might be accounted for by the presence of a small amount of specular reflexion. But as

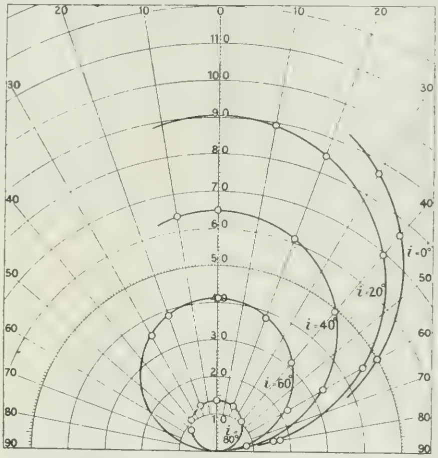


FIG. 13.—H. Wright. Angles ε. Family of different ι.

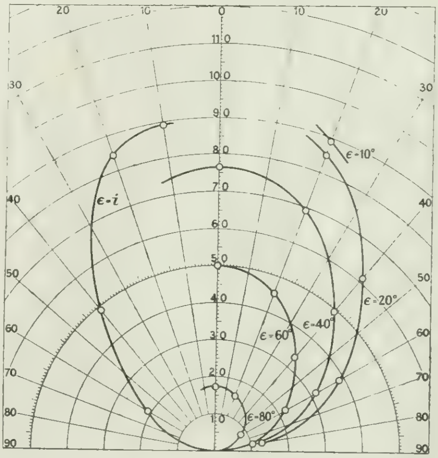


FIG. 14.—H. Wright. Angles ι. Family of different ε.

they are not so inclined the observations are unaccountable. It is true that they agree with result No. 5, but they are directly opposed to the results of other workers, and it seems probable that there was some serious instrumental error. Polarisation may be suspected, and a polarisation photometer depending on the square of the tangent of the rotation of a Nicol prism, with its serious loss of light is not an instrument to be recommended for so simple a photometric problem as this.

In a short paper in 1912, P. G. Nutting* suggested that there are four different types of diffused reflexion (Fig. 15) but he supported them neither by citation of experiments nor reference to any authority. In this paper, Nutting went into the mathematics of Bouguer's hypothetical layer of reflecting spheres, but arrived at no useful conclusion.

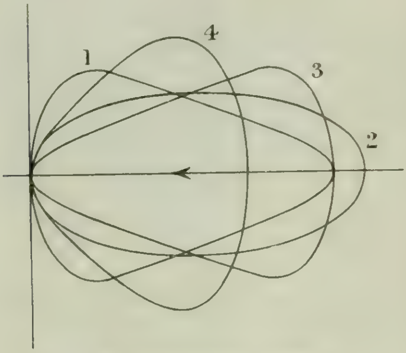


FIG. 15.—Nutting's types.

My own work on this subject began in 1891, when I was engaged in making measurements of illumination in London streets. Eight years before this I had carried out a good deal of work of this kind with photometers invented by Sir William Preece, or by instruments devised by us in collaboration. The principle of street photometry on which I have always worked is to receive the whole of the available illumination on a horizontal screen or test plane either at a few inches or at a height of one metre above the ground. Light falls on the instrument from many directions and angles, and the brightness of the screen should be a measure of the sum of the illumination received from all lamps visible from it. In designing an illumination photometer for street work it was therefore important that the horizontal screen receiving the illumination to be measured should "obey Lambert's law." The screen was perforated by a sharp-edged hole, generally star-shaped, and of about 400 to 500 sq. mm. in area, and below this, inside the instrument, there was another screen the brightness of which could be so adjusted that, a balance being obtained, the hole seemed almost to disappear. In order that a definite part of the inner screen should always be seen through the hole, it is necessary to view the instrument from approximately a definite direction. Until 1906 I viewed it from the perpendicular direction normal to it. With such an instrument, capable of an accuracy of comparison of 2 to 3 per cent., it is easy to test a screen for angles of incidence at any inclination with the normal to the screen or at any azimuth with reference to the plane in which the observer's eye is situated excepting only his actual line of sight and a few degrees on either side of it. If I had kept records of all the good, bad and indifferent kinds of screen which I tried I should have a long list of substances which more or less obey Lambert's law, together with much information about their departure from it. For many years I adopted good white Bristol board, with the glaze removed by gentle rubbing with a damp cloth or with dry pumice powder.

Most of my subsequent work on diffused reflexion has been in connection with improvements in the precision of my illumination photometer.

I regard my work on this subject to be unfinished. It was stopped on account of my change of residence in 1914. Some of it should be repeated with apparatus capable of yielding higher precision; conditions should be varied over greater ranges; and a greater variety of substances should be examined.

Before describing my experimental work I will give a sketch of the explanation which I have to offer.

---

* P. G. Nutting. "Diffuse Reflexion and Transmission of Light. Illuminating Engineering Soc., America. Sixth Annual Convention, Sept., 1912. See also *Trans. Ill. Eng. Soc., America,* Vol. X., 353–393, July, 1915.

Bouguer experimentally arrived at his Numeratrix of Roughness, and recognised that if the cosine law were followed, this curve would be a circle. But he found a marked divergence. He proceeded to compare the two curves by drawing a circle circumscribing his numeratrix. The major axis of the latter became a diameter of the circle. The differences represented an apparent deficiency of reflecting power, to which he specifically referred, and for which he strove to account.

Bouguer was, of course, right in drawing a circle to represent the cosine law, but he should have inscribed it, not circumscribed it. Fig. 16 is Bouguer's curve in which the largest possible circle that osculates at the pole has been inscribed. The observed difference is an excess and is due to specular reflexion. Useful as polar curves are in many cases, they are in general not so convenient for comparison of differences as curves plotted with rectangular co-ordinates. (Christian Wiener noted this.) With rectangular co-ordinates Lambert's law becomes a cosine curve, Bouguer's curve a bell-shaped curve astride of it (Fig 17). The difference between the two being plotted is suggestive of several well-known curves, and *a priori* considerations point to the probability curve or curve of frequency (Fig. 18). The dotted line is the normal frequency curve. The statistical function which is present is the orientation of complete generality of the innumerable reflecting facets imagined by Bouguer. In Figs. 3, 17 and 18 Bouguer's notation is preserved.

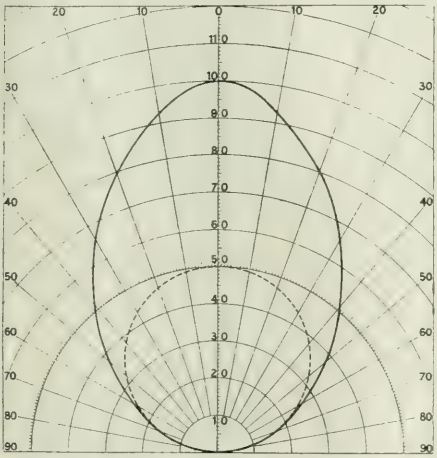


FIG. 16.—Bouguer's curve with osculating circle.

Bouguer seems to have considered that all reflexion is ultimately specular, but Lambert's hypothesis of a diffusive reflexion distinct from specular reflexion agrees well with the observed facts.

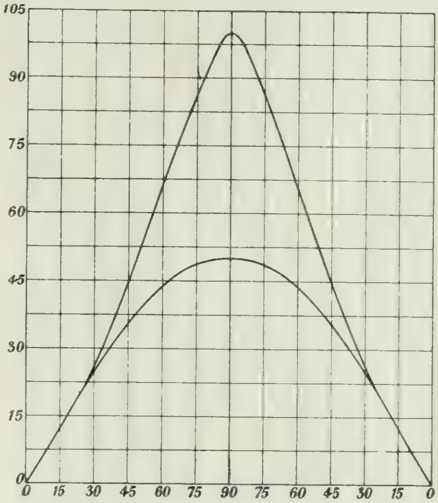


FIG. 17.—Bouguer's results with cosine curve.

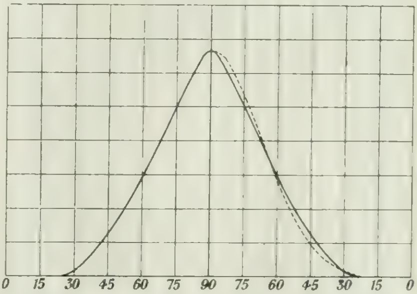


FIG. 18.—Difference between the curves of Fig. 17. Probability curve dotted.

Partial polish may be of two kinds. If a matt surface such as that of finely-ground glass is subjected to the treatment usually applied for polishing glass, the highest points will be truncated and form small portions of a reflecting plane. The degree of polish depends largely on the proportion of the area of the parts so polished to the whole surface. Such polishing has been discussed by Lord Rayleigh and by Sir W. Beilby. While such a process of polishing progresses simple specular reflexion capable of giving a clear image is developed.

But the semi-polish of cardboard and such substances is of a different kind. The specular reflexion is not regular enough to give an image except at grazing angles. It is true that with light incident at any given angle, the maximum light reflected in any direction is at an angle equal to that of the angle of incidence, but the remainder is reflected at other angles; and it appears that the chance of reflexion at any angle differing from the symmetrical angle of emergence is a function of that difference. The greater the difference the less likely is light reflected. Hence the appearance of the probability function.

It is not profitable to speculate at length on the nature of the surface under consideration. The matt portion undoubtedly scatters light in all directions. The semi-polish may consist of minute facets inclined at various angles, but more probably consists of curved surfaces.

Applying this analysis to Blondel's Fig. 5 it becomes Fig. 19. The diameter of the osculating circle used was 0·7 of the maximum ordinate in Fig. 5.

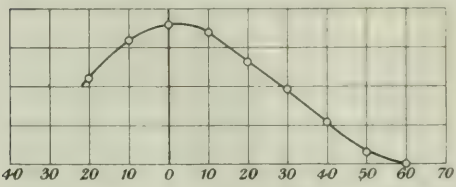


FIG. 19.—Analysis of Blondel's curve, Fig. 5.

It may be assumed that Lambert's law of diffused reflexion is strictly true for an ideal substance, and it is worth while to give some consideration to this matter. It is well known that fine powders closely obey this law. It is an elementary fact in ordinary catoptrics that the reflecting power of a polished reflector is greater at large angles, and that even rough surfaces which show little or no specular reflexion at ordinary angles act as reflectors at grazing angles of incidence.* It is probable that little or no accurate work on semi-polished surfaces has been done on account of the difficulty of defining the degree of such semi-polish.

Angstrom* in his experiments on diffusion of radiant heat made matt surfaces by smoking and by decantation from liquid suspension, which showed no reflexion even at high angles of incidence. For the purpose of producing a plane surface some such treatment of the powder is necessary. For determining the zero of an instrument which I designed† for measuring the gloss on printed paper, I found that ordinary domestic whiting sifted in a layer of a few millimetres' thickness and pressed down flat with a sheet of glass, which is afterwards removed, gives an excellent result.

C. C. Hutchins‡ in experiments on the reflexion of heat used magnesia smoke, and G. B. Pegram§ in a paper read before the New York Academy of Science, measured reflexion from various surfaces, and found that the best was fine plaster dust allowed to settle from suspension in the air. This "follows pretty closely the old Lambert's or cosine law . . . with some departure when the angles were very large. With all other surfaces the departure was very great for angles greater than 70°."

If the reflexion which follows the cosine law consists entirely of Lambert's "second part," and if his "third part," in which the incident line penetrates a little into a superficial lamina and emerges, is to be excluded, the ideal substance must be perfectly opaque. Lommel suggests that it must be perfectly white, which involves the same condition; for if two white substances are placed side by side, one being opaque and the other allowing a small quantity of light to penetrate, only a part of this light can re-emerge, and the latter substance will appear grey compared with the former.

Good thick white blotting paper is a very useful material in certain optical experiments. It is fairly matt and has a fairly standard albedo or whiteness, found by Dr. E. Sumpner to be about 82 per cent. Examined under a microscope it appears to be a felt of glass-like fibres. Zollner found the albedo of fresh snow to be 78 per cent. In both cases a small amount of specular reflexion is present, and it is doubtful whether either of these observers took it into account. Finely-powdered colourless glass is a substance of this type. Nutting has used powdered boracic acid* and found a reflecting power of 86·4 per cent. An experiment should be made with a thick layer of fine powder of a transparent substance to ascertain whether it has any specular reflexion. There is no *a priori* reason (*pace* Lommel) why it should. A spoonful of table salt flattened down with a knife shows no general specular reflexion that can be observed by the eye.

---

* This is clearly explained in R. W. Wood's "Physical Optics," p. 43.

* *Loc. cit.*

† Report on the Influence of School Books upon Eyesight. British Association, 1914.

‡ *American Journal of Science*, Vol. VI., p. 376, 1898.

§ *Science*, New York, Vol. XIII., p. 148.

I plotted my experimental results with both polar and rectangular co-ordinates.

The curves in Fig. 20 are taken from my book,† page 93. The experiments made in October, 1895, were made in the manner there described for the purpose of ascertaining the best angle for the screens of the Conroy type of photometer. They are not therefore comparable with the measurements of Bouguer and the subsequent ones of Christian Wiener, as the conditions were somewhat different, but they are, perhaps, the earliest examples of the graphical representation of different degrees or modes of specular reflexion. In these, white blotting paper has the highest albedo, and exhibits no appreciable specular reflexion. With ordinary Bristol board specular reflexion begins to be marked at about 20 degrees, and attains a maximum when at 45° the angle of incidence was equal to the angle of emergence, and remained appreciable up to about 55 degrees. This specular reflexion was entirely removed (so far as the somewhat crude mode of experiment revealed) by rubbing with pumice flour, and at the same time the albedo was reduced. A piece of white china having a still lower albedo showed no specular reflexion until near 45 degrees, when the brightness suddenly flashed up far beyond the range of the apparatus. It disappeared as suddenly. This indicates that the unglazed substance of the ware was behaving all the time as a matt body, and that the specular reflexion was due solely to the glaze. The angle through which it persisted was the angle subtended by the source of light. Highly glazed enamelled card behaved much in the same way.

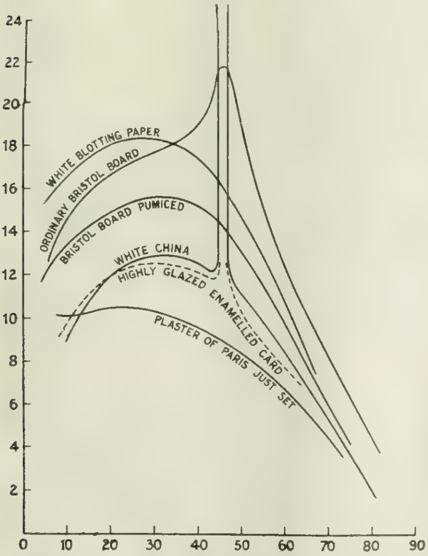


FIG. 20.—Experiments on partial polish.

My more recent work on diffused reflexion begun in December, 1908, was on white celluloid, the material adopted by Messrs. Everett, Edgcumbe & Co. for the screens of my illumination photometer, but a good deal of attention was paid also to pumiced Bristol board. White celluloid was, indeed, a rather happy choice. The makers matt it by sand blasting, but I prefer to finish it with pumice flour rubbed on with plenty of water, and using a similar piece of celluloid as a tool. Cleaning it with a clean, damp cloth tends to polish it, and it is easy at any time to bring it back to a standard surface with pumice flour and water. This material is of a type intermediate between that of blotting paper or powdered glass (which are essentially transparent substances having a white matt appearance due to specular reflexion from innumerable facets), and magnesia, chalk or plaster of paris, which appear to consist of opaque, or nearly opaque, particles. White celluloid consists of such particles embedded in a fairly transparent material of low refractive index. Its rather poor albedo is probably due to its translucency and the presence of a Lambert lamina of appreciable thickness. Although great efforts have been made by American inventors to produce a photometer screen which will faithfully obey Lambert's law, my experience shows that any errors which remain with a white celluloid screen properly prepared and used are well below other errors, such as light reflected from clouds at night, which are inseparable from outdoor photometry.

---

* "A New Method and an Instrument for Determining the Reflecting Power of Opaque Bodies." P. G. Nutting. *Trans. of Ill. Eng. Soc., U.S.A.*, Vol. VII., p. 616, Nov., 1912.

† "Trotter on Illumination: its Distribution and Measurement." London, 1911. Macmillan & Co.

My investigation of the "angle errors" of my photometer consisted in measuring and reducing to a negligible quantity the specular reflexion of the celluloid screen. While engaged on this a photometer was sent to me for examination by an engineer who had found considerable angle errors. These were clearly due to the fact that his assistant had spent so much care in keeping the screen clean that he had given it a partial polish. My note book contains some 600 to 700 observations on this screen, with the practical result to which I have alluded, namely, that the specular reflexion and errors arising from it may be made negligible.

But another result was a collection of a considerable amount of information on partial polish which consists of diffused reflexion accompanied by a small quantity of specular reflexion, and this prompted me to examine the subject more closely and under wider conditions than those imposed by the construction of my illumination photometer. While it was easy to produce a partial polish on the matt celluloid it did not seem easy to specify the amount of such polish, and I returned, therefore, to the examination of Bristol board, which is a well-known material of fairly uniform quality, and I made a few experiments with a visiting card.

I will first dismiss the work on celluloid. The source of light was moved on a radial arm through a semi-circle, at a constant distance from the star hole in the screen. The line of sight was in the plane of the source of light, and was inclined at 20 degrees to the normal to the screen. No reading could be taken at 20 degrees on one side as my head was in the way. When the source of light was at 20 degrees on the other side, the angle of incidence being equal to the angle of reflexion, the specular reflexion was a maximum. The tests, which were made in July, 1909, were, as I have said, for the purpose of examining the angle errors of the photometer. Results are given in my book* referred to an arbitrary circle. They are here re-drawn and osculating circles have been fitted. Fig. 21 is the curve for the semi-polished screen already mentioned. Fig. 22 is for the same screen, but with the line of sight in a plane at 90° with the plane in which the source of light moved. In other

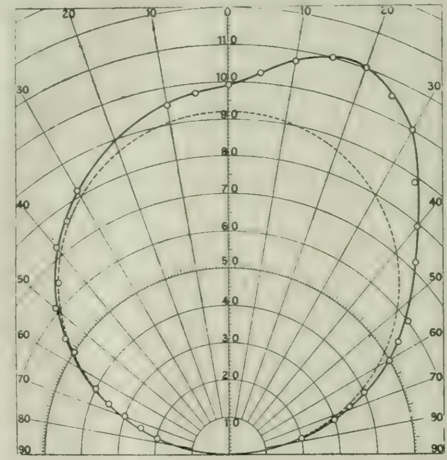


FIG. 21.—Semi-polished white celluloid, viewed in plane with light.

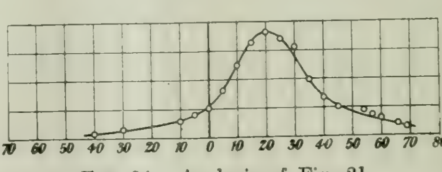


FIG. 24.—Analysis of Fig. 21.

---

* "Illumination," p. 220.

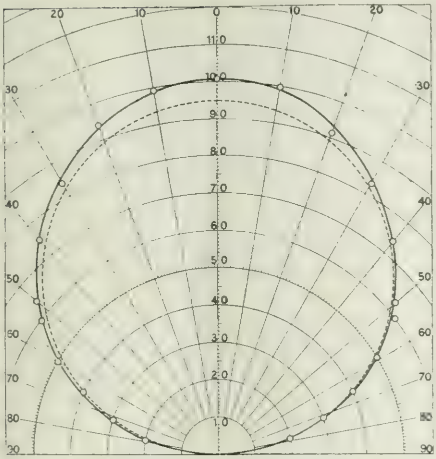


FIG. 22.—Semi-polished white celluloid, viewed at 90° to plane of light.

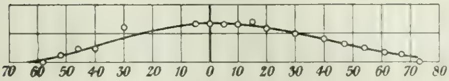


FIG. 25.—Analysis of Fig. 22.

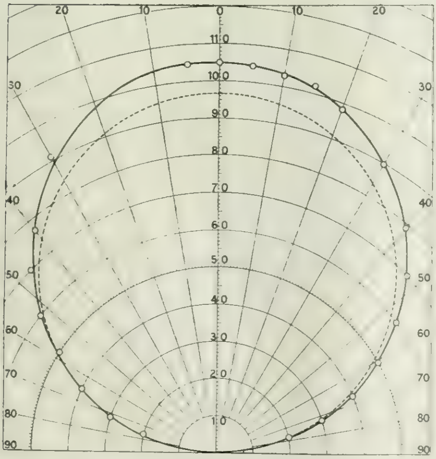


FIG. 23.—White celluloid matted, viewed in plane with light.

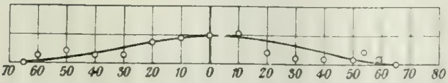


FIG. 26.—Analysis of Fig. 23.

words, I moved one quarter of the way round the instrument and repeated the tests. (This, of course, is the position in which it should always be used in practice.) It is evident that the specular reflexion is largely reduced. The celluloid screen was then surfaced with pumice flour and water. Fig. 23 gives the result, repeating the original test with the line of sight in the plane of the source of light.

In these tests the instrumental errors ought not to have exceeded 2 per cent. The radial lamp and the photometer lamp were connected in series, and current was taken from public supply mains. Variations in voltage of the supply did not disappear, as was anticipated, owing to differences in the lamps. There were also difficulties with screening and reflected light.

Three readings were generally taken for each setting, and the mean difference from the mean was from 1½ to 2 per cent. The angle was set first in measurements from 0° to 60°, and beyond 60° the photometer was set for some reading, and the angle was adjusted to give a balance; the error in angle was well within 1°, generally about ½°.

These curves may now be analysed, that is to say, an attempt may be made to separate the diffused or Lambert reflexion from the specular. There are two ways of doing this. One is to draw an osculating circle within the polar curve, the other is to plot the rectangular co-ordinates and fit a cosine curve to the flanks. The former is the more easy. It must be done by trial and error. A few trials with a pair of dividers will show the maximum radius that can be used. In the case of Fig. 21 a radius of 46·5 has been adopted. The circle having been drawn, the radial differences are measured and are set off from a linear scale of angles as in Fig. 24. There has clearly been some instrumental error on the right hand side. The left hand side gives an excellent curve strongly resembling the probability or frequency curve.

In Fig. 22 the radius of the osculating circle is 47·5. Fig. 25 gives the radial difference. There are some very poor readings, but enough to suggest a curve. In Fig. 23 the radius of the circle is 48·5.

The differences are given in Fig. 26. These three examples, having the angle of emission ϵ constant at 20°, and with varying angles of incidence are opposed to Dr. Wright's fifth conclusion.

These three sets of tests were, perhaps, good enough for the purpose for which they were originally intended, and in December, 1909, I constructed an apparatus for the further and more exact investigation of diffused reflexion.

The diagram Fig. 27 shows the scheme. The substance to be examined (S_1) was mounted in a holder and could be rotated on a vertical axis coincident with one of its edges. A vertical sighting wire O enabled the direction of view to be fixed. The angle ϵ measured on the graduated circle is the angle of aspect or emission as it is generally called. The specimen was illuminated by a lamp, L_1, carried on a radial bar. The angle of incidence ι was measured on another graduated circle. A back screen S_2 rotating on a vertical axis could be set at any convenient angle which need not be measured. This back screen was illuminated by a lamp, L_2, mounted on a light carriage running smoothly on a photometer bar about 100 inches (2·54 m.) long. The specimen being set at any angle and illuminated by light falling on it at any given incidence, the carriage was moved until the brightness of the two screens was the same, as in Bouguer's experiments, and the left hand edge of the specimen appeared to vanish.

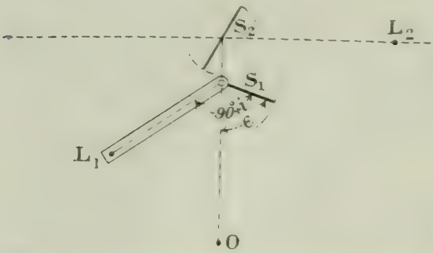


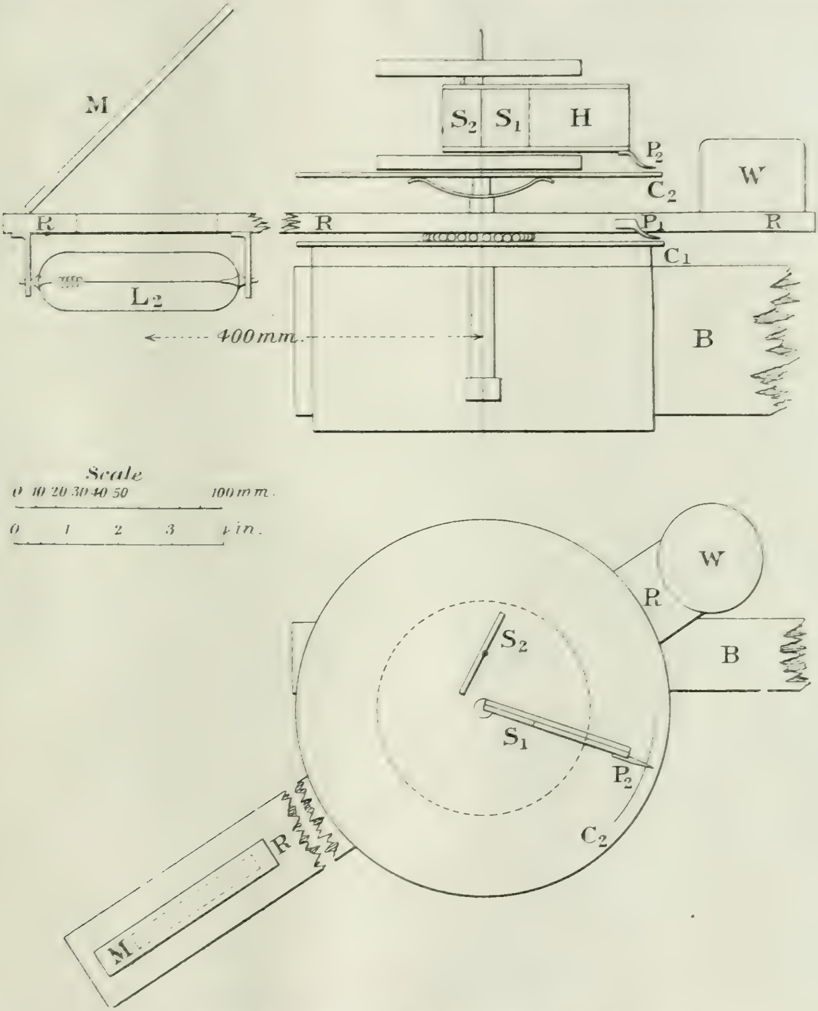
Fig. 27.—Scheme of method of investigation of reflexion.

Fig. 28 shows some of the details in elevation, the radial bar R being swung round to a position parallel to the photometer bench B. The lamp, L_2, was placed below the bar, the light passed up through a slot shown dotted and was reflected by a strip of mirror, M, 10 mm. wide, set at 45° on the screen S_2. This arrangement was adopted to enable the incident ray to be brought close to the line of sight. The distance of the image of the lamp to the axial edge of the screen, S_1, was about 400 mm. The bar was carried on ball bearings and was counterpoised by the weight W. It was provided with a pointer P_1 to read on the graduated circle C_1. The specimen holder H was provided with a pointer P_2 reading on the graduated circle C_2.

Fig. 29 shows a plan of the arrangement, the radial bar being swung out at an angle of 35° with the photometer bar. A number of diaphragms, hoods and screens were used to prevent any light from lamp, L_1, falling on any part of the apparatus except the specimen, S_1, and any light from L_2 falling on any part except the back screen, S_2. Imperfections in this screening were a troublesome source of error. Still greater trouble was experienced with the lamps. Specially made tube lamps with straight metal filaments were generally used because so much was promised of them, but they were at that date badly made, and altered in candlepower very appreciably even in one evening's work. Repeat readings were continually made, and much work had to be discarded when serious changes had been discovered. Striated fields due to bad glass also gave trouble. I intended to reconstruct the apparatus, using one lamp only with a vertical filament set above the axis of S_1, and using a mirror instead of L_2, but this was not carried out.

The photometer bar was provided with three scales. The upper one was a scale of inches and tenths. The middle one was in square roots of inches. Graduation 10 on the middle scale corresponded with 31622 on the upper scale. The lower scale was in reciprocals of the middle one. Graduation 1 on the lower scale corresponded with 10 on the middle scale, but was read as 100. This was generally used as the maximum. The radial bar was adjusted to give maximum brightness on S_1, and the back screen was adjusted to give a balance when L_2 was at 100. The maximum illumination was about one foot-candle.

A piece of mirror put in the holder in place of the specimen S_1 allowed the filament of L_1 to be observed for the purposes of adjustment: and when turned so that I could see my eye reflected in it, in a line with the sighting wire, the zero angle could be adjusted.



FIGS. 28 and 29.—Apparatus for investigation of reflexion.

After a few experiments on visiting cards, a series on Bristol board was begun. This is a good quality of white cardboard, having a slight polish. Six sets of measurements were made at angles ε of emission of 0°, 20°, 40°, 60°, 70°, and 75°, and at each 10° of incidence ι with more numerous measurements at angles nearly opposite to the angle of emission. The object was to obtain for analysis a series of polar curves. A convenient maximum of brightness was arranged for each set, and as these maxima were not related, the curves were not comparable with each other as to scale. In order to effect such a comparison, two sets of measurements were made with 0° incidence, and varying angles of emission, and by means of this the six sets of curves could be reduced to the same scale.

The results were by no means satisfactory, but they were promising. These were the last that I made, as I was obliged to stop experimental work at the end of January, 1910, and have had no opportunity of proceeding with it. I considered that they were not good enough for publication, and this present description is written with the object of suggesting their completion.

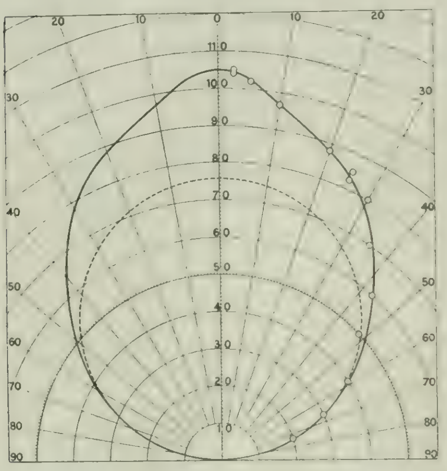


FIG. 30.—Bristol board. ε = 0 deg.

Fig. 30 is the curve obtained with Bristol board for ε = 0°, and since it is bilaterally symmetrical, only one half was measured. The maximum was intended for 100 arbitrary units. The glare near the maximum made accurate measurement difficult, though greater success was met with in more difficult cases when further experience had been gained. An inscribed circle of diameter 76 is drawn, and Fig. 31 gives the differences. The reading at 47½ is obviously wrong.

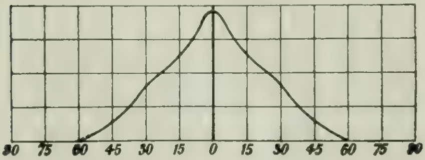


FIG. 31.—Analysis of Fig. 30.

The curve for ε = 20° is not good enough for reproduction. The curve for 40° is shown in Fig. 32, and is fitted with an osculating circle of diameter 66.

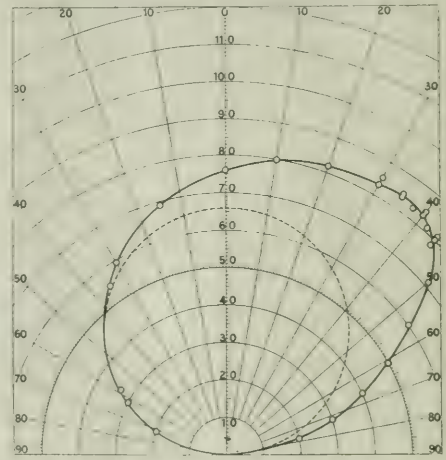


FIG. 32.—Bristol board. ε = 40 deg.

The differences are given in Fig. 33. With ε = 60° the increasing reflecting power is very marked, as appears in Fig. 34, which is plotted to half the radial scale of the other curves. The differences from a circle of diameter 33 are given in Fig. 35. Observations with an angle of emission of 70° and with 75° were not very satisfactory. The family of five curves reduced to the same scale is given in Fig. 36.

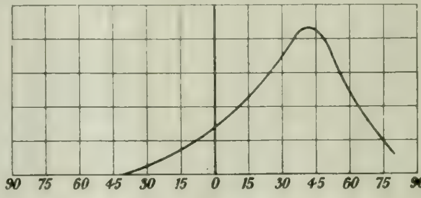


FIG. 33.—Analysis of Fig. 32.

The differences representing the specular reflexion separated from the scattered reflexion give curves having a strong resemblance to skew probability curves, but more than that cannot be said until the work has been repeated with greater precision.

Although these sets of observations were made without inter-related scale, it was noticed that, contrary to expectation, for a given incident illumination, the brightness varied considerably with the angle of emission, and hence the set of observations already referred to were made with $\iota = 0^\circ$, and varying ε.

Until recently, experimental photometric work has consisted chiefly in measurements of luminous intensity by some kind of photometer suitable for comparing the intensity or candlepower of two sources of light. It would be difficult to examine the relation between scattered reflexion and the angle of emission with such a photometer, for at large angles the surface under tests would offer such a small projected area that a very small quantity of light would be reflected. We must, therefore, go back to Bouguer's principle of comparing brightness—a principle which has been applied in the design of several modern illumination photometers.

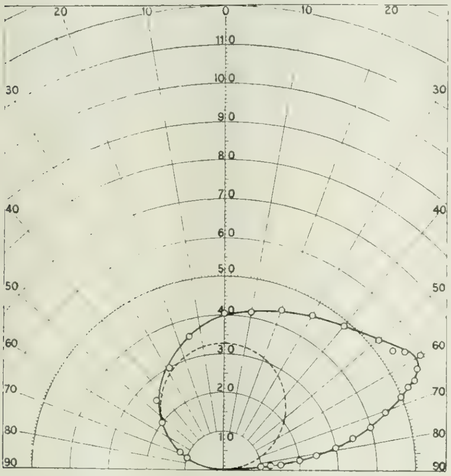


FIG. 34.—Bristol board. $\varepsilon = 60$ deg.

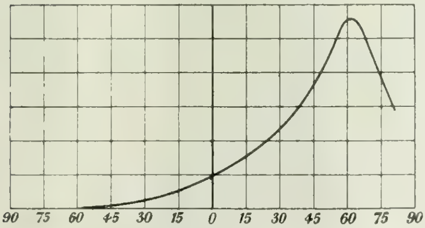


FIG. 35.—Analysis of Fig. 34.

Unfortunately only two sets, one of 48 observations and another of 78, were made. Of these, the second was, perhaps, the best, and the means are given in Fig. 37. It appears that with Bristol board, after a fall in the region of specular reflexion, the reflecting power diminishes regularly as the angle of emission increases. The curve in Fig. 37 is approximately an equiangular spiral, and plotting with rectangular co-ordinates as in Fig. 38, the equation to the straight line is $93^\circ - 0{\cdot}33\varepsilon$, where ε is the angle of emission measured in degrees, or generally,

$$b = b_1 - a\varepsilon$$

where b is the normal or maximum brightness, b_1 the brightness at any angle ε, and a is a constant. The total range of brightness observed in this case was about 32 per cent. This agrees generally with Wiener's experi-

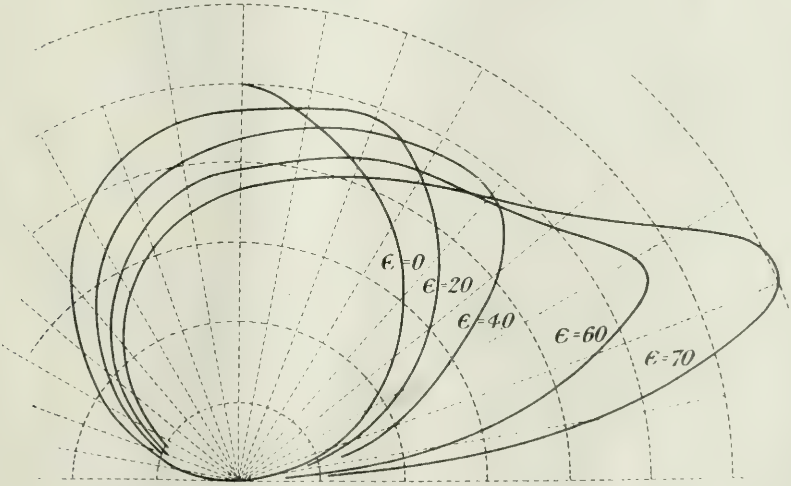


FIG. 36.—Family of curves of reflexion from Bristol board.

ment shown in Figs. 8 and 12, where the range was 40 per cent. If the reflecting power had not fallen off, if Lambert's suggestion had been true, and in accordance with the idea commonly held, the curve in Fig. 37 would have been a semi-circle, and the line in Fig. 38 would have been horizontal.

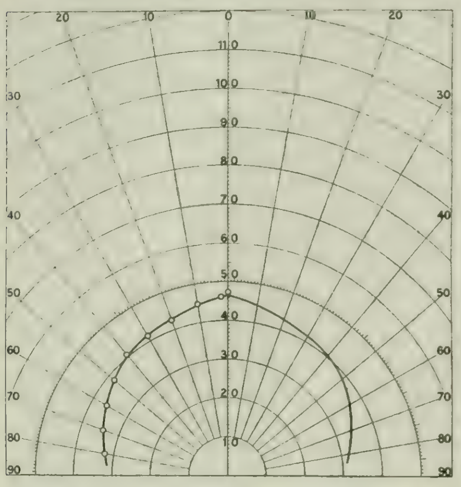


Fig. 37.—Bristol board. $\iota = 0$ deg. ε varies.

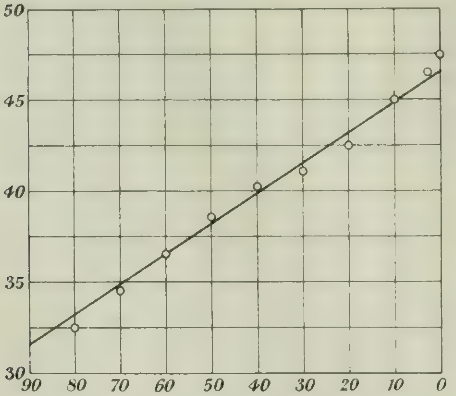


Fig. 38.—Bristol board. $\iota = 0$ deg. ε varies.

A rough experiment with a flattened layer of carbonate of magnesia gave a range of about 18 per cent. This is contrary to received ideas, and must be taken with reserve until it has been confirmed by further experiment.

On the other hand, *a priori* considerations support such a relation. Let a small particle of a matt surface have three facets, *A*, *B* and *C* (Fig. 39), each being matt, not polished. The particle is illuminated by light falling on the surface at normal incidence, and is viewed in the same direction. A full view is presented of facet *A*, which is most brightly illuminated, while slanting views are seen of *B* and *C* which receive illuminations varying as the cosines of the angles of incidence. In Fig. 40 the surface, illuminated as before, is seen from a considerable angle of emission, and the brightest facet *A* is seen obliquely, while the darker facet *C* presents a full view. Were this all, it would prove too much, but at large angles of emission the lower parts of the particles are hidden from view by the upper parts of adjacent particles, and there is repeated reflexion between the lower parts.

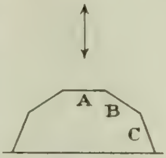


Fig. 39.
Facetted particle.

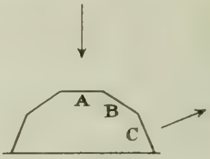


Fig. 40.
Facetted particle.

Experiments should be made with matt surfaces at various angles of emission and at varying angles of incidence, and care should be taken that they are as matt as possible. To say that a fine powder such as carbonate of magnesia remains matt when compressed into a block is too general a statement. Much depends on the surface against which it is pressed. A moderate pressure with one's fingers on a piece of glass will impart such a surface to a thin layer of carbonate of magnesia that at a large or grazing angle, it will clearly reflect window bars or the filament of an electric lamp.

From the series of experiments shown in Fig. 36 a set of readings for $\varepsilon = \iota$ can be picked out. These are plotted in Fig. 41. This is the curve which Bouguer called the Numeratrix of Roughness. All my other curves are for a given ε and varying ι. In Fig. 42 the differences from a circle of diameter 60 are shown. The dotted line is the normal probability curve, and the fit appears to be good enough to claim some attention.

PART II.—DIFFUSED TRANSMISSION.

Bouguer and Lambert both wrote on the passage of light through transparent and translucent media, including air. Little attention has been given to the mode in which light is scattered by transmission through translucent media, though many curves have been published in America showing results with different kinds of glass, and a few theoretical remarks have been made on them.

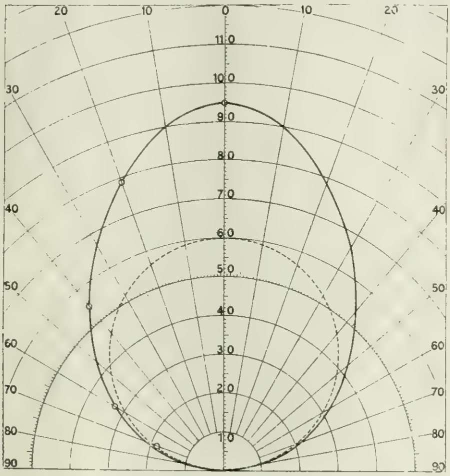


FIG. 41.—Bouguer's "numeratrix" curve. Bristol board.

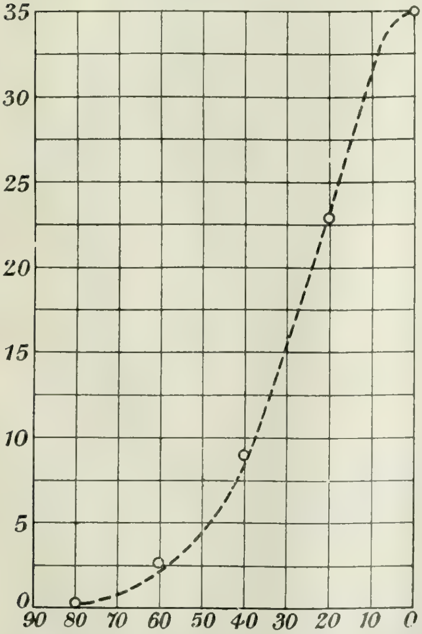


FIG. 42.—Analysis of Fig. 41. Normal probability curve dotted.

The original form of Bunsen photometer was a box containing a small gas flame, and having an opening on one side covered with paper marked with grease. The box was turned to face first one and then the other of the lamps to be compared, the system of double weighing being used. The distance of the lamp under test was adjusted until the grease spot disappeared. The first illumination photometer of Sir William Preece resembled the original Bunsen instrument, as it consisted of a box containing a small electric lamp, the top was covered with a screen of white paper on which was a grease spot. The light of the lamp was adjusted by a resistance to give a balance. But this balance depended on the direction from which the screen was viewed. In the modern form of Bunsen photometer mirrors are used to enable both sides of the spot to be seen. Complete disappearance on both sides at once cannot be obtained.

In 1883, while assisting Sir William Preece, I investigated the different behaviour of plain blotting paper and of waxed paper at different angles of view, but I have no notes of my observations. I took the matter up again in March, 1908, and made up an apparatus for carrying the investigation further. The diagram (Fig. 43) shows the scheme. On a photometric bar *A*, *B*, a screen *C* perforated by a star-shaped hole about 10 mm. wide is set at a convenient angle, and its brightness is adjusted by moving a lamp mounted on a smoothly running carriage. A radial bar turning on a vertical axis in line with the centre of the star hole, carried the translucent specimen at *D*, and a tubular electric lamp with a straight filament, giving about five candlepower, at E. The specimen could be rotated on a vertical axis, and its position read on a graduated circle; another graduated circle gave the position of the radial bar. A sighting point was fixed at *F* to the other end of the radial bar, and a fixed sighting point was arranged at *O*. The lamp *A* was set at 100 on the photometric scale, the lamp *E* was adjusted until a balance of brightness was found, and under good conditions the star-shaped perforation at C disappeared. The bar E F was turned through a measured angle, and the lamp A was moved until a new balance was obtained as seen from O. At large angles it was better to set the lamp A at some round number, and to move the radial bar until a balance was found, and to record the angle. A considerable elaboration of screens, diaphragms, and hoods was necessary to avoid stray light.

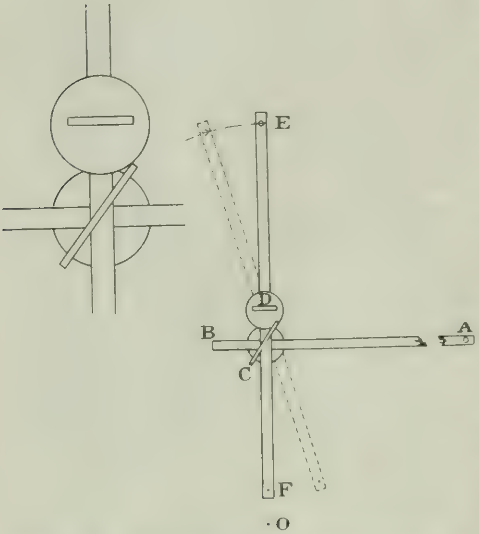


FIG. 43.—Apparatus for investigation of transmission.

In the first set of experiments D was always square with E F ; in the second, E F remained fixed, and facing O, and the lamp moved round D as a centre. The distance A C was from one to eight feet (say 2·5 m.) E C was about 15 inches (380 mm.). The specimens tried were blotting paper soaked in stearin, and with the stearin partly removed with a hot iron, plain blotting paper, tracing paper, tracing cloth, and other kinds of paper, including the standard kind used in the photometer of the Metropolitan Gas Referees. Thin films of paraffin and of stearin on glass, small slabs of paraffin wax about 50 mm. long, 15 mm. wide, and from 1·4 to 3·3 mm. thick, and ground glass of various fineness of grain were used. It was intended to try opal glass, but there are so many kinds and qualities that this was postponed until the method had been developed.

More than 80 sets of experiments were made, with some 15 or 20 settings of angles in each set, and many of the observations were repeated three or four times. By experience and improvements in the apparatus, precision was improved, and instrumental errors due to stray light or to partial cutting off of the light by the screening diaphragms were eliminated. A disadvantage of this method is that if there is any appreciable difference in the apparent texture of the perforated screen and of the specimen, the star hole does not disappear. This was marked in the case of a £5 note.

Prof. Blondel, to whom I communicated some of my results on reflexion, suggested in his letter to me of August 23rd, 1895, the method shown in Fig. 44. "I believe," he wrote, "that the same method with some little modification can be employed too, for the measurement of transmitive powers. The star screen is fixed perpendicularly on the bar OB and turns with it, the shaft being O. You can compare in that way the illumination on the star screen received *normally* from the lamp L_1 at variable distance,

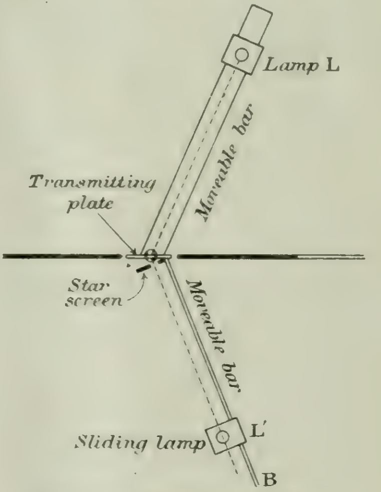


FIG. 44.—Blondel's suggestion.

the apparent brilliancy of the transmitting plate seen through the hole at various angles and lighted by lamp *L* at a fixed distance under various incidences. I think that by choosing a very little star, quite close to the axle *O*, you can get good measurement under every angle."

Some early experiments in March, 1908, with blotting paper, Gas Referees' paper, ground glass, glass with a film of paraffin wax about 1 mm. thick, yielded polar curves given in Fig. 45. Instrumental errors were present, but the results were encouraging, and suggested that there were several different types of scattering. This, however, was due to the unfamiliar appearance of the curve, which, when plotted with rectangular co-ordinates in Fig. 46, indicates that there is only one type, with a considerable range of constant. Figs. 47 and 48 give the result of experiments bearing on the Bunsen grease spot, and show scattering produced by blotting paper soaked in stearin, plain blotting paper, and two intermediate states with the stearin partly ironed out.

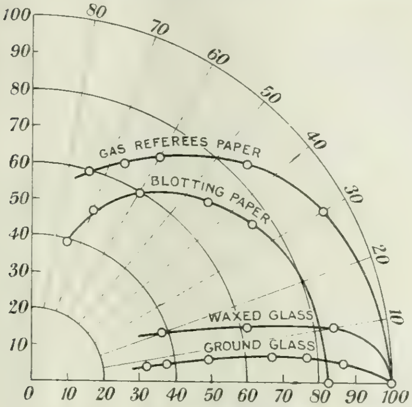


FIG. 45.—Transmission experiments.

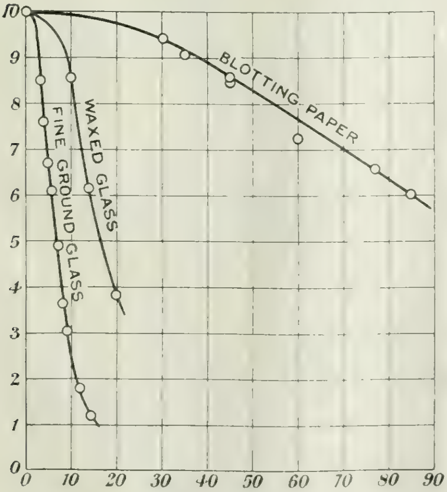


FIG. 46.—Transmission experiments.

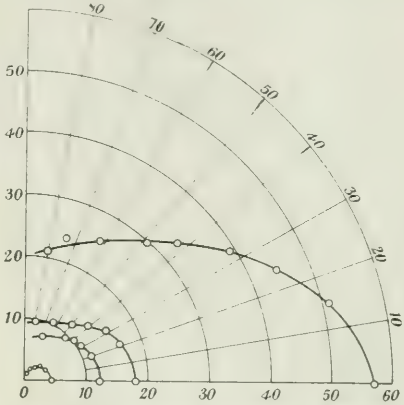


FIG. 47.—Blotting paper and stearin.

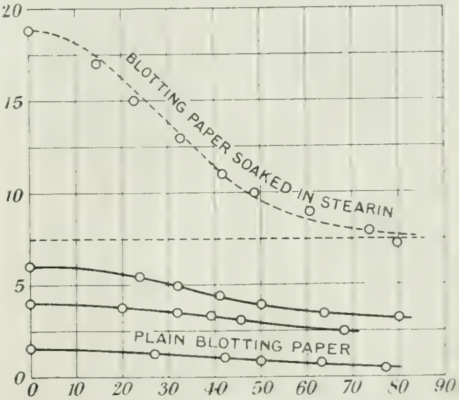


FIG. 48.—Normal probability curve dotted.

With ground glass, ground, as is usual on one side only, the effect when the polished side receives the incident light is, of course, not the same as when it is reversed. Fig. 49 is a specimen of several experiments. I have found no rational method of fitting the probability curve to the curve for ground glass.

My intention was to investigate the scattering of light by various translucent

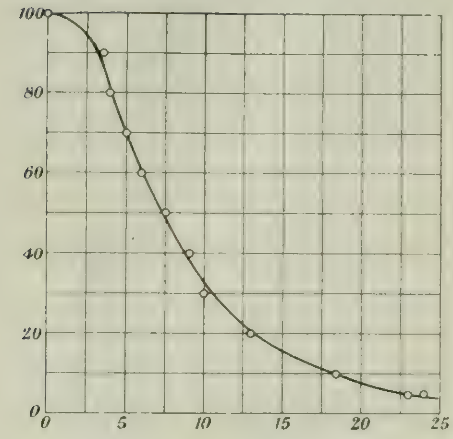


FIG. 49.—Ground glass.

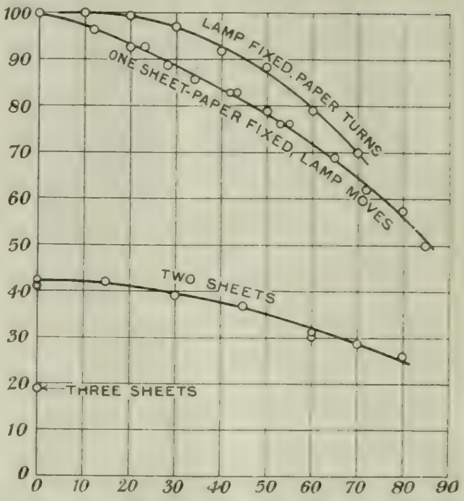


FIG. 50.—Metropolitan Gas Referees' paper.

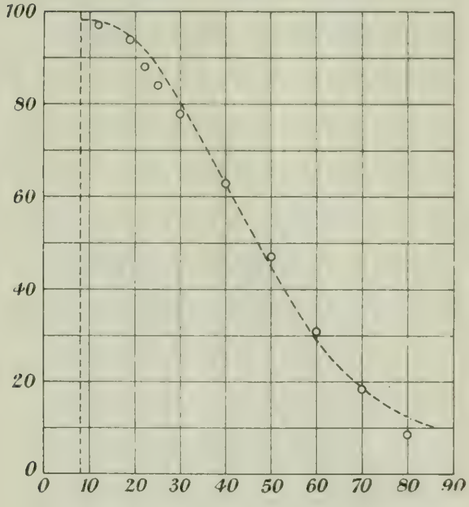


FIG. 51.—Gas Referees' paper and probability curve, with displaced axis.

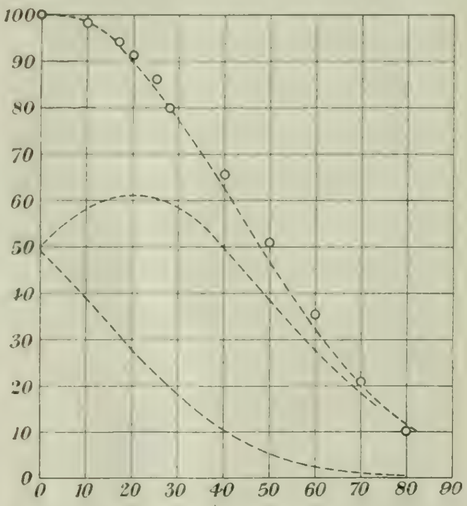


FIG. 52.—Gas Referees' paper and sum of two probability curves.

substances and to find the laws followed by different types. I wished to pay special attention to opal glass with the view of arriving at the characteristic behaviour of different kinds, and their applicability to different uses, and at a specification which would define various qualities between buyer and seller. I proposed to investigate the relation of scattering to thickness of medium, by using a thin jelly containing a definite amount of some white powder in suspension. I had a small glass tank made for this, with pieces of glass of different thicknesses, to displace the jelly, but I have not used it.

A complete investigation of opal glass would, of course, include its reflecting power and absorption as well as its scattering.*

Fig. 50 is for the paper used in the Gas Referees' photometer. Figs. 51 and 52 are attempts to fit probability curves to the curve for this paper. In Fig. 51 the axis is displaced to the right, and in Fig. 52 the sum of two probability curves is given.

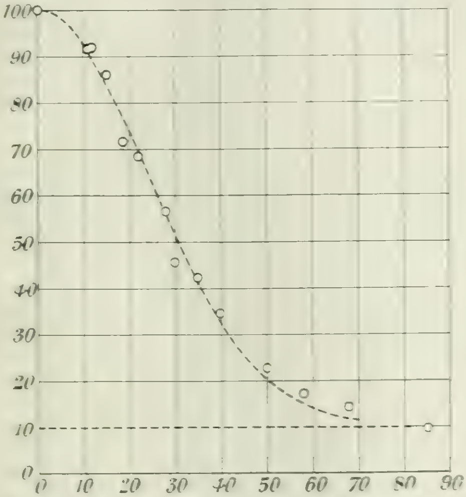


Fig. 53.—Paraffin wax. 2 mm. thick and probability curve.

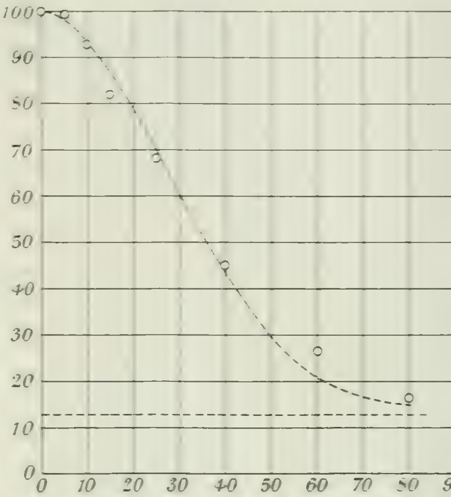


Fig. 54.—Paraffin wax. 1·4 mm. thick and probability curve.

In the fitting of calculated curves to observed points there is always a temptation to fudge or cook the result. No rational excuse is offered for the expedients adopted in the last two figures. But in Figs. 53 and 54, showing th scattering of light by paraffin slabs of 2 mm. and 1·4 mm. thickness, and in the case of the upper curve in Fig. 4 the shifting of the base of the probability curve is rational. Its height, show by the dotted line, obviously indicates the brightness of the wax as seen on edge.

This account has been written with the intention of placing the materials in the hands of others who have facilities for completing the investigation.

---

* M. Luckiesh in the *Electrical World*, Vol. LX., Nov. 16, 1912, and gave curves for various kinds of opal glass designated by their trade names. See the *Electrician*, Vol. LXXI., p. 562, July 11, 1913.

REFLECTORS WITH WHITE DIFFUSING INTERIORS.

A DISCUSSION has been appearing in the Continental papers regarding the properties of reflectors with inner surfaces coated with a white and approximately matt material. It has been shown by Halbertsmat that provided the surface is approximately evenly illuminated it can be regarded as equivalent to a luminous disc in the plane of the light source, and thus adding to the natural polar curve of the light source a supple-mentary distribution in the form of a circle. It has been sought to make this generalisation wider by applying it to any form of reflector with a dead white interior, but it appears that this would only be true with certain types. In any case the light-distribution from any reflector of this type is easily calculable and it is evident that it would not be easy, with the usual form, to obtain either a markedly concentrating or "extensive" polar curve.

THE ILLUMINATING ENGINEERING SOCIETY OF JAPAN.

We have received from the Illuminating Engineering Society in Japan, through the medium of Mr. M. Uchisaka, who is on a visit to the Electrotechnical Congress in this country, the following particulars of the Society in Japan, which we are glad to note is making good progress.*

Papers and Lectures.—The Society regularly publishes its transactions, and during the present year the following papers have been published: Artistic Aspects of Electric Lighting Fixtures by T. Adachi; Typical Curves of Light Distribution by Y. Yoshioka; War and Illumination, with special reference to Searchlights, by Major S. Uchida; Notes on the Beck Searchlight by Y. Murakami; the Measurements of Spherical Reduction Factors of Incandescent Electric Lamps by M. Igari; Report No. 1 on Electric Lamp Standardisation for Vacuum Tungsten Lamps. Lectures have also been delivered by Major S. Uchida on War and Illumination, and Mr. M. So on Visibility and the Eye.

Committee on Standardisation of Electric Lamps.—This Committee has been in co-operation with the Japanese Electrotechnical Committee of the International Electrotechnical Commission. A specification for vacuum metal filament lamps has been issued, and a similar specification for gas-filled lamps is in course of preparation. Of this Committee Dr. G. Yamakawa is Chairman, Mr. Y. Shinjo (Vice-Chairman), and the Secretaries are Mr. T. Nomura and Mr. R. Mitsuda.

Committee on Nomenclature.—This Committee has held regular monthly meetings, and the subject is still under consideration. The Chairman is Dr. Yamakawa: Vice-Chairman, Dr. I. Nakahara: Secretaries, Messrs. Y. Fukuda and M. Uchisaka.

Other committees include that on Membership Committees on School Lighting, Street Lighting, and Factory Lighting, in course of formation

A scheme for the offer of prizes for designs of illuminating apparatus is under consideration.

Membership.—Dr. G. Yamakawa, ex-President, has been created the first Honorary Member. The distribution of members is as follows:—

Honorary Members	..	1
Sustaining Members	..	110
Regular Members	..	543
Associate Members	..	36

There has been an increase of 5 per cent. during the current fiscal year.

Officers of the Society.—The present officers of the Society (1919-1920) are as follows:—

President: Dr. C. Asano, Professor at the Tokyo Imperial University.

Vice-Presidents: Dr. I. Nakahara, Tokyo Imperial University; and Mr. Y. Shinjo, President of the Tokyo Electric Co.

Managers: Mr. T. Hatano, Dr. T. Kujirai, Mr. R. Mitsuda, Mr. S. Otahara, Mr. M. Tsukasaki, Mr. M. Uchisaka.

There is also a series of forty Councillors.

---

* Some previous reference to the formation of this Society was made in the *Illuminating Engineer* for April, 1918, and February, 1919.

THE TRANSMISSION OF COLOURED LIGHT THROUGH FOG.*

By C. L. Utterback.

Experiments were made on artificial fogs of thick, medium and slight density, but only experiments on the medium variety, which is stated to be similar to the fogs met with in Philadelphia, are recorded. The fogs were produced by allowing water vapour to condense within a tube 190·5 cms. long and 16 cms. in diameter, with a central square box 40 cms. square. By keeping the air space from which air was drawn into the tube well filled with dust particles a fog of practically the same density could be reproduced. The density could be checked by observation of the intensity of white light transmitted through the fog, but no other method of specifying the density was attempted. The source of light was a 6—8 volt 21 candlepower automobile lamp, the rays of which were made nearly parallel by a condensing lens before entering the tube. The intensity of the light could be altered by an adjustable stop in front of the lens. The beam of light was received on a white diffusing plate the brightness of which was studied by an illumination photometer. Light of any desired range of wave-length was obtained by the use of special transmission screens. The inside of the tube was painted dead black to prevent reflection of scattered light.

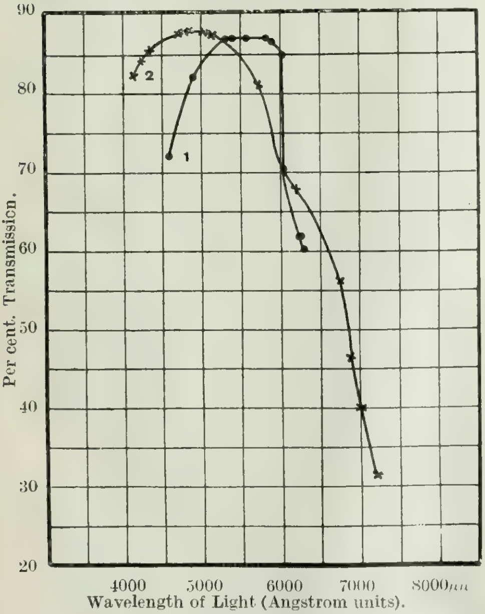


Fig. 1. Transmission of light of different colours through (1) artificial fog, (2) pure water.

In the accompanying figure Curve No. 2 relates to some previous researches by Dr. T. Ewan on the transmission of coloured light through pure water,* while Curve No. 1 shows the results obtained by the author for the artificial fog produced as described above. The transmission throughout the spectrum is not quite the same in each of these two cases, but the results support the conclusion that light of wave-length between the limits, 5,300—5,900$\mu\mu$ is best adapted for penetrating fog.

In the discussion of this paper Prof. T. D. Cope refers to some similar experiments carried out by the German Lighthouse Board about 1903, with a box covered with glass at both ends and filled with steam condensed by a water jacket. Taking the absorption for the yellow ("D" line) as 100, the absorptions in the red and violet respectively were 108·7 and 87·7. These results are striking as suggesting that the well-known tendency of all lights to shift towards the red end of the spectrum, as exemplified by the aspects of the sun and moon when rising and setting, are not due to the presence of water vapour. Mention is made of the fact that an arc light of 1,000,000 rated candlepower installed by the German Government on the Island of Heligoland was found much less effective in penetrating fog than an oil light of 10,000 candlepower.† Notwithstanding the results of the German Lighthouse Board for water-vapour, red and yellow rays thus appear to penetrate fog much better than blue rays. Mr. Luckiesh in a paper read before the American Illuminating Engineering Society in September, 1915, mentioned an experience with automobile lights on in a fog, confirming this impression. Four observers agreed that distant objects were better seen by a headlight with a greenish-yellow screen than with a white light, although the screen reduced the candlepower by 25 per cent. In the *Journal of the Franklin Institute* for March, 1919, Professor Bancroft gave a summary of experiments proving that water absorbs red and transmits green. It would appear, therefore, that there is a marked difference between the absorption due to water vapour and that due to particles of dust, smoke or haze, which seem to transmit red and yellow light best.

---

* Abstract of a paper before the Illum. Eng. Soc. (U.S.A.) *Trans.*, Vol. XIV, No. 3, April 30th, 1919.

* *Proc. Roy. Soc., London*, 57, pp. 117–162, 1894.

† *Proc. Railway Signal Association*, 1905, p. 291.

Messrs. E. Karrer and E. P. T. Tyndall remark that the mechanism by which light is diffused may be subdivided as follows :—

(1) Diffusion by molecules of gases in the atmosphere.

(2) Diffusion by particles of water and water vapour.

(3) Diffusion by solid particles suspended in the atmosphere. Examples of the first are the blue sky and the path of the searchlight beam on clear nights and at high altitudes; examples of the second may be seen during rainy, foggy and misty weather; examples of the third in hazy and smoky atmospheres.

The nature of the absorption may thus differ considerably according to whether one or other of these conditions prevails, and it is doubtful whether any artificial fog can correctly represent the natural variety. Diffusion by molecules and very small insulating particles varies inversely as the fourth power of the wave-length, and thus rapidly suppresses the transmission of blue and violet light. When the particles become comparable in size to the wave-length of light and larger, this law no longer holds, and the nature of the diffusion will depend on the optical and electrical properties of the material of the particles, and upon their shape.

Mr. C. L. Utterback, in reply to the discussion, stated that further experiments on the effect of dust particles in a fog, and on the effect of outdoor fogs, would be made and that the amount of water vapour present would be noted.

THE EFFECT ON THE EYE OF LIGHT OF DIFFERENT COLOURS.

THE general impression that yellow light is less fatiguing to the eye than white light seems to find some justification, so far as artificial light is concerned, in some recent researches by C. E. Ferree and G. Rand. communicated to the American Illuminating Engineering Society. The method of judging fatigue was similar to that used in the previous series of researches by these investigators, *i.e.*, the criterion of "efficiency" of the eye was the relative period during which type appeared respective clear and blurred when gazed at continuously for three minutes. During a three hours' test the percentage of time blurred, according to these experiments, tends to steadily increase, indicating that the eye is becoming fatigued.

One series of experiments compared the light from a kerosene lamp with tungsten filament electric lamps, the illumination being the same for each illuminant and the light coming from behind the observer so that no question of glare from the source could arise. In these circumstances it appeared that the loss in efficiency of the eye was least with the yellow oil light. This set of experiments has since been supplemented by tests of a series of gas mantles, having a progressively increasing decreasing percentage of ceria and thus yielding light changing gradually from yellow to bluish green. Here, too, the results appeared to favour the more yellowish light.

LIGHTING SAFETY ORDERS IN CALIFORNIA.

WE observe that the Industrial Accident Commission of California is preparing a set of General Lighting Safety Orders and is using for this illustrations appearing in the Code of Industrial Lighting drafted by the American Illuminating Engineering Society.

LIGHTING IN FACTORIES AND SHIPYARDS.

Notes on the Report of H.M. Chief Inspector of Factories for 1918.

THIS Report contains a number of references to factory lighting. Thus Mr. H. J. Wilson (Inspector for the Northern Division) mentions, among notable steps tending to diminish accidents in shipyards, the appointment of men, one for each boat, to supervise lighting alone. Mr. Whiteside (Glasgow) also comments on the danger of accidents arising through uncovered openings not being observed by workers. He remarks :—

"Even with good lighting it is wonderful how readily one fails to observe an uncovered opening in the decks, particularly the lower ones, and it is often through those which have to be open to allow men and material to pass that workers fall. The dim light, the drab colour of the decks and walls, all contribute to camouflage the dangerous openings. I have often thought that the risk might be lessened by painting the edge of such holes and openings with a white band, 8 in. to 12 in. broad, round the hole. This, of course, would require frequent renewal, but might easily be done by the man appointed to see that the manhole covers are maintained in position. One could hardly fail then to notice the position of the opening. . . The suggestion has been placed before one of the largest firms on the Clyde, and they immediately decided to put it into practice, considering the idea a good one."

Reports from the North-East Coast emphasise the fact that full benefit has not been obtained from Regulations owing to war conditions. The restriction regarding lights, very strictly enforced in this area, rendered it impossible to provide the lighting required on the ships, and a number of accidents attributable to this cause were reported.

The report of the Electrical Inspector (Mr. G. S. Ram) also refers at some length to the question of lighting, as follows :—

"Much consideration has been given during the last few years to the science of illumination and to the design of efficient fittings for distributing the light to the best advantage, according to the special circumstances for which it is required ; the matter having been of importance during the war owing to the large amount of overtime and night work resorted to in many works. For many years factory lighting by electricity was dependent upon the arc lamp for general illumination, with the attendant troubles of trimming, cleaning and expense of carbons, and upon the carbon filament glow lamp of very low efficiency for localised lighting of individual machines, work benches, etc. This localised lighting necessitates a large number of pendants, brackets or other fittings wherever the lights are required. The improvements which were effected some years ago in gas lighting would probably have led to gas largely superseding electricity for factory lighting, had not the metallic filament glow lamp, with its corresponding improvements, been introduced just in time to re-establish the relative advantages of the latter. The carbon filament lamp, although nominally taking 4 watts per candle, seldom achieved more than 5 or even 6 watts per candle after being in use a short time. The metallic filament lamp has enormously improved this result, at the same time giving a whiter and more useful quality of light. Recently the gas-filled or 'half-watt' lamp has again doubled the efficiency, so that eight or ten times the light is obtained for the same consumption of electrical energy compared with the carbon filament lamp of ten or fifteen years ago. The half-watt lamps are made in sizes up to 1,000 candlepower, so that it is now possible largely to dispense with localised lighting by providing a comparatively few of these lamps suitably placed. At the same time there have been useful developments in localised lighting. One which is particularly suitable for engineering machine shops provides for small ten-watt lamps, such as are used in motor-car headlights, in specially designed reflectors attached to fittings having universal joints so that the lamps may be put in any position. The pressure is only 10 or 12 volts, being reduced from the supply pressure by a small transformer for every ten or fifteen lamps. The wiring is concentric, the metal tubing of the fittings forming the return conductor and being earthed at the transformer. This construction, of course, greatly simplifies the mechanism of the universal joints. Besides being very robust, and therefore suitable for machine shops, the advantages claimed are excellent lighting of the work, as much as 15 foot-candles being obtained at fifteen inches from the lamp, economy in the amount of electricity consumed, and particularly in regard to lamp renewals, the small lamp withstanding the inevitable vibration and rough usage under conditions which would be disastrous to lamps of ordinary pressures, say 200 volts, with their far more delicate filaments. A further advantage is no doubt in safety owing to the very low voltage. Some excellent examples of scientific lighting are to be seen in some of the new works. On the other hand, I have seen examples of very bad lighting with half-watt lamps, the lamps being unscreened and placed where they cause a glare and are probably harmful to the eyesight of persons employed. Similar unscientific and harmful examples may be seen by anyone in many of the shop-windows in the West End at the present time; unshaded lamps being placed so that they shine into the eyes of the onlooker, causing such a glare that they fail utterly to show up the goods in the window although in a blaze of light."

The Report, as a whole, also contains much matter of great general interest, special reference being made to such questions as hours of work and industrial fatigue, labour-saving appliances, welfare and "Safety First" methods. It is satisfactory to note that the increased amount of machinery used and the introduction of female labour during the period of the war have not led to a corresponding increase in the number of reportable accidents. Many of the Inspectors' reports point to a decrease; thus in the Midland Division the total number of accidents of all kinds reported was 35,706 in 1914, but only 29,556 and 28,699 in 1917 and 1918 respectively; the decrease, however, being entirely in accidents of the non-machinery class. This decrease is ascribed to the greater care exercised by foremen and managers in works where women were largely introduced, and the extension of the "Safety First" movement.

EMERGENCY SHIPYARD LIGHTING.

The problems arising in the lighting of ships under construction are dealt with in a note by Mr. H. A. Horner in the August issue of The Transactions of the Illuminating Engineering Society in the United States. Ships under construction are commonly surrounded by temporary scaffolding, which is constantly changing as the work proceeds. This renders lighting a matter of considerable difficulty. Floodlights installed between the scaffolding and the work have been tried, but the close proximity of the light to the work, the sharp shadows thrown, and the obstruction due to groups of workmen moving between the light and the object cause difficulties. An alternative method is to festoon the scaffolding with incandescent lamps, thus distributing the lighting sources. Many of these lamps are unavoidably broken, and as the scaffolding is removed or added to, their positions have to be constantly altered. Experience shows that for such work 110-volt lamps are much to be preferred to the 220-volt type on account of their stronger filaments. Within the ship structure lamps tapped off distributing mains and attached to adjustable iron clamps so that they can be located at any desired point are commonly used. It is worth noting that a foreman with some knowledge of illumination can frequently devise quite serviceable units for such emergency work from ordinary dishpans, etc.; often an intimate knowledge of the nature of the work and the lighting requirements may go far to replace efficiently designed units. Roofed in sheds where construction is undertaken naturally present an easier problem.

MAINTENANCE IN INDUSTRIAL LIGHTING.

As illustrating the attention now being paid to the upkeep of industrial lighting, as an essential to proper conditions in the interests of health and safety, mention may be made of a bulletin entitled "The Lighting of Industrial Establishments," prepared by Mr. D. H. Tuck, Assistant Physicist to the United States Public Health Service, and reprinted from the Public Health Reports of this body.

The pamphlet refers to the importance of an adequate hygienic and well-distributed system of artificial illumination, which is now becoming well understood, although the need for regular maintenance and cleaning is apt to be overlooked in some cases.

Among the causes of progressive diminution in lighting efficiency are mentioned: (1) Continued use; (2) dirt and dust accumulations on lamps and reflectors; (3) burn-outs and breaks; (4) reflectors becoming cracked, broken, or missing; (5) mechanical injury to connections. It has been shown that the loss of light due to dust and dirt collecting on lamps and fittings may amount to 50 per cent. for equipment that has not been cleaned for four months; also that quite a small quantity of dust, so small as not to be readily visible by casual inspection, may reduce the light by 20 per cent. Of great consequence, also, is the maintenance of reflectors, which have an important influence on the distribution of light, directing it where it is chiefly needed. If a reflector is broken and not replaced, 50 per cent. of the light previously received from this lamp on the working plane may be lost by being distributed elsewhere. Moreover, the loss in efficiency and productive power occurring in an installation which suffers neglect may amount to a considerable sum in the course of the year.

The following table illustrates the loss in efficiency that may arise through various defective conditions:—

Condition.	Efficiency of Maintenance.
Lamps dirty	80 per cent.
Lamps very dirty ..	70 ,,
Lamps blackened due to ageing	80 ,,
Lamps too large or too small for reflector	80 ,,
Lamp missing, broken, or filament shortened ..	50 ,,
Reflector dirty	80 ,,
Reflector very dirty ..	70 ,,
Reflector cracked	80 ,,
Reflector broken or missing	50 ,,
Connections loose or drop cord bare	80 ,,

The following may be taken as a typical example from one department of a shop recently inspected:—

General overhead units. Shop No. 304, Tool Room:—

12 units, lamps dirty, reflectors dirty.
3 units, lamps dirty, reflectors missing.
2 units, lamps dirty, reflectors very dirty.
9 units, lamps very dirty, reflectors very dirty.
1 unit, lamps very dirty, reflector missing.
1 unit, lamps dirty, reflectors clean.
2 units, lamps dirty, reflectors dirty, lamp blackened.

The efficiency of maintenance would thus work out somewhat as follows:—

$12 \times 0{\cdot}8 \times 0{\cdot}8$	7·68
$3 \times 0{\cdot}8 \times 0{\cdot}5$	1·20
$2 \times 0{\cdot}8 \times 0{\cdot}7$	1·12
$9 \times 0{\cdot}7 \times 0{\cdot}7$	4·40
$1 \times 0{\cdot}7 \times 0{\cdot}5$	0·35
$1 \times 0{\cdot}8$	0·80
$2 \times 0{\cdot}8 \times 0{\cdot}8 \times 0{\cdot}8$	1·02
30	16·57

Efficiency of maintenance is thus equal to:—

$$\frac{16{\cdot}57 \times 100}{30} = 55{\cdot}2 \text{ per cent.}$$

By measurement with an illumination photometer it was shown that the average illumination could be doubled when the efficiency of installations was brought up to 100 per cent.

A department of maintenance of artificial lighting is a most valuable asset in a workshop. Reports of inspectors, adopting a system of rating such as that outlined above, should be made at periodical intervals. The ratings allow considerable latitude and an efficiency of maintenance of 100 per cent., on the above basis, is considered quite practicable. By adopting such practice a large economic waste could be avoided and losses due to decreased production, inferior products, accidents and defective eyesight reduced to a minimum.

HIGH CURRENT SEARCHLIGHTS AND OTHER SPECIAL LAMPS FOR WAR WORK.

THE *General Electric Review* (U.S.A.) for August continues its summary of work undertaken by the General Electric Co. of America in connection with the war. Among other interesting items we note that the manufacture of searchlight carbons for very high current densities was undertaken, electrodes suitable for 200 amperes being first prepared, and ultimately electrodes for 500 amperes, a higher current than had ever been used in a searchlight before.

Another interesting item was the design of " blinker lamps " for signalling on the Morse code. The Navy desired to increase the range, but the use of a heavier filament (thus securing higher candlepower) was attended by the objection that the rate of heating and cooling was retarded and the speed of signalling accordingly reduced. Ultimately use was made of the fact that hydrogen has the greatest heat-conductivity of any gas, and that if pure it would not affect the filament. Lamps with filaments in an atmosphere of hydrogen gave the desired range and speed of signalling.

Among other problems mentioned are the production of smoke screens, the development of specially heavy bullets made of tungsten, and the development of a new fluorescent screen for rapid X-ray work.

INSPECTION AND LIFE TESTS OF INCANDESCENT LAMPS.

IT is stated in the *Electrical World* that the total number of lamps offered for delivery to the U.S.A. Government purchasing departments during the past fiscal year was over 5,000,000. Of these about 600,000, or 12 per cent., were rejected on the initial inspection at the factory, which covers the mechanical qualities of lamps and their rating in regard to power consumption. During the year nearly 3,500 lamps (as samples) were subjected to life-tests, and with few exceptions the lamps, both vacuum and gas-filled, had a life exceeding the 1.000 hours required by the specification.

UNIVERSITY COLLEGE, LONDON.

FORTHCOMING LECTURE ON ILLUMINATION.

WE have received a copy of the syllabus of a series of interesting public lectures which are to take place at University College, London, during the autumn. Among these we notice one by Mr. W. C. Clinton, Assistant Professor in the Electrical Engineering Department, on " Recent Developments in Public and Private Lighting." The lecture, which will doubtless be of interest to many of our readers, is to take place on Friday, October 24th, at 5 p.m. Tickets can be obtained on application to the Secretary, University College, Gower Street, London, W.C.1.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

SHOP-WINDOW LIGHTING AND BUSINESS.

THE relation between shop-lighting and volume of business is admittedly close. Even a casual observer cannot fail to notice a window lighted in an attractive manner, whereas people who gaze into a badly-lighted window merely do so because their attention has been attracted by some object of intrinsic interest, in spite of the poor lighting. The essential points in good window lighting are to conceal the lamps from view and to illuminate the objects displayed—not to exhibit lamps and fittings. These aims must be attained as economically as possible, *i.e.*, as much of the light as possible must be directed where it is actually needed.

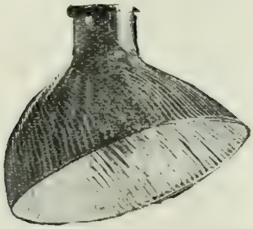


FIG. 1.—" X-Ray " mirror reflector for shop window lighting.

The British Thomson-Houston Co., Ltd., draw attention to the special advantages of Mazda gas-filled (" half-watt ") lamps in X-Ray reflectors for such work and the accompanying illustrations show the operation of these appliances. The lamps are mounted along the top edge of the window behind the fascia (or a shallow curtain), and the appropriate type of reflector and spacing is adopted according to the dimensions of the window, so as to flood its contents evenly with light.

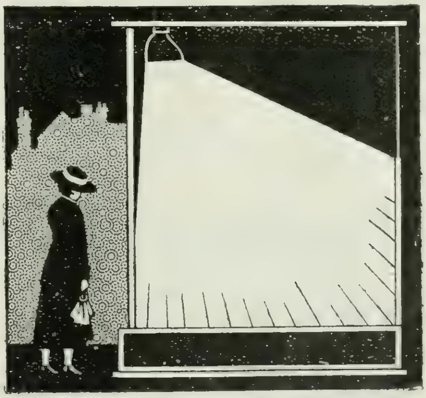


FIG. 2.—Diagram showing lighting effect obtained with " X-Ray " reflectors. The light is concentrated on the display; none is wasted on the pavement or ceiling, and the lamps are invisible to people looking in the window.

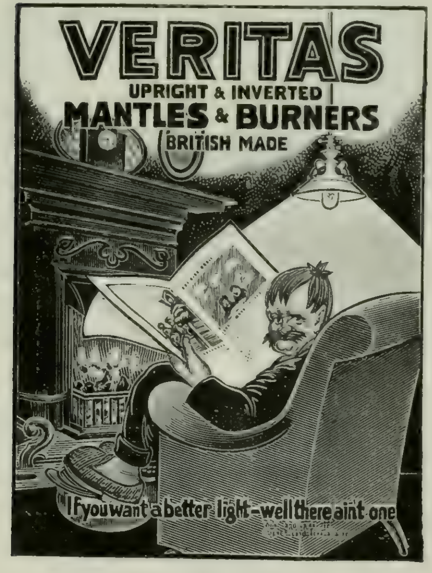
REDUCTION IN PRICE OF GAS-FILLED LAMPS.

We are glad to observe that the leading lamp manufacturers have issued a revised list of prices for gas-filled ("half-watt") lamps, which is reproduced below. This diminution will doubtless have the effect of further popularising this type of lamp, for which there has been a big demand since the outbreak of war.

Rating in watts.	Reduction in price. From—		To	
	s.	d.	s.	d.
15	4	6	4	3
30	5	6	5	0
60	6	6	5	6
100	12	6	10	6
150	16	6	13	6
200	20	0	16	0
300 L.V.	25	0	20	0
300 H.V.	30	0	24	0
500	30	0	24	0
1,000	40	0	30	0
1,500	50	0	37	6

POSTERS OF VERITAS MANTLES.

We are informed that Messrs. Falk Stadelmann & Co., Ltd., are again arranging to advertise their Veritas mantles by posters on hoardings, and have adopted the following design:



"ZEUS" MANTLES.

We understand that the "Zeus" mantle, a product of the Convex Incandescent Mantle Co., Ltd., of 13, Henrietta Street, London, W.C.2, is an entirely British product. The name "Zeus" ("The God of Light") is appropriate. The war has emphasised the desirability of British sources of supply of incandescent mantles, and as much reconstruction work in lighting has been deferred during the war there should be a keen demand for such accessories during the coming winter.

SIEMENS BROS. & CO., LTD.

Messrs. Siemens Bros. & Co., Ltd., announce that five members of their staff, officers in the Company's cable ship "Faraday," received letters of commendation from the Admiralty for their services during the war, and a letter has been sent to each officer by the Lords Commissioners of the Admiralty. The letter states that the work performed by the cable ships during the war, carried out under extremely arduous and hazardous conditions, has been of the greatest assistance to the British and Allied cause, the maintenance of the communications of the Empire being of the highest importance to naval and military operations.

OSRAM ATMOS LAMPS.

A leaflet issued by the General Electric Co., Ltd., announcing the reduced prices for Osram Atmos (gas-filled) lamps, traces the development of these lamps since 1913, and the subsequent work done at the Osram Lamp Works, Hammersmith. In the first instance nitrogen was invariably used as the gaseous element in these lamps; but it was subsequently found that argon was preferable for the lower candlepowers. Up to 1914 no commercial use was known for argon, but since then an argon-producing plant (stated to be the first of its kind in this country) has been erected at the Osram Lamp Works, where the spiralising of the filaments for gas-filled lamps is also carried out.

INDEX, September, 1919.

PAGE
Careers for Ex-Service Men 278
Diffused Reflexion and the Transmission of Light. By A. P. Trotter .. 243
Editorial. L. Gaster 239
Eye, Effect of Coloured Light on 270
Factories and Shipyards, Lighting of 271
High Current Searchlights for War Work 274
Illuminating Engineering Society in Japan, The 268
Industrial League and Council, The 278
Maintenance in Industrial Lighting 273

Reviews of Books and Publications Received:-
Fuel Economy, by W. H. Booth Journal of the Society of Glass Technology Abstracts of Papers in Scientific Papers and Periodicals —"Surplus"—*The General Electric Review* (U.S.A.) 277

Shipyards, Emergency Lighting in 272
Transmission of Coloured Light through Fog, The 269

Topical and Industrial Section :—
Shop-Window Lighting—Reduction in Price of Gas-filled Lamps, &c. —Posters of Veritas Mantles—"Zeus" Mantles—Siemens Bros. & Co., Ltd. Osram Atmos Lamps 275

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

Fuel Economy. By W. H. Booth. (*S. Rentell and Co., Ltd., London. 2s. 6d. net. pp.* 92.)

This little book is based upon the lectures given by the author under the auspices of the London Coal Smoke Abatement Society and the London County Council. In the present edition a few revisions have been made and some notes on water softening added. There are five main sections in which such questions as the calorific value of fuels, the effect of draught, lighting fires, use of dampers, types of boilers, principles of combustion, etc., are discussed, and much practical information for the benefit of stokers given. At the same time the scientific principles involved are explained. We notice that the book is dedicated to the author's 1909-10 class of stokers at the Borough Road Polytechnic, and we think it most desirable, especially in these days of fuel economy, that those in charge of furnaces and boilers should study such matters as are here discussed

Journal of the Society of Glass Technology.

The issue of the above journal for August contains a series of seven papers, dealing mainly with raw materials and manufacturing processes and implements used in glass manufacture, and an address by the President (Mr. S. N. Jenkinson) on the value of co-operation. At the end of the volume there is the usual series of abstracts and reviews of current papers and articles, to which we have previously drawn attention as a useful feature in the publications of scientific societies.

Abstracts of Papers in Scientific Transactions and Periodicals (issued by the Institution of Civil Engineers).

We are interested to observe that the Abstracts of Papers in Scientific Transactions and Periodicals, previously incorporated in the Minutes of Procedure of the Institution of Civil Engineers, is now being issued in pamphlet form as a separate publication. It is hoped that this arrangement will render the Abstracts available more promptly and regularly. Numbers will be compiled and printed quarterly with name and subject indexes. The general aim of the Abstracts is to give a brief summary of the more important engineering and other scientific information contained in periodicals published outside the United Kingdom. The first number of the Abstracts issued in their new form deals with many interesting papers. It is remarked that the number is affected by the fact that normal conditions of supply of foreign periodicals has not yet been restored, but it is hoped that this difficulty will be removed at an early date.

"Surplus" (the Official Organ of the Surplus Government Property Disposal Board), M.O.M., Armament Buildings, Whitehall Place, London, S.W.1.

UNDER the above title a most useful publication is being issued by the Ministry of Munitions, being a catalogue of Government property for sale. The journal (price 3d.) is issued on the first and fifteenth of each month, and the first number is a business-like production, with its contents well classified. Of special interest are the sections dealing with plant and machinery, and there is also a Lands and Factory Section, wherein twelve National Factories are mentioned as available for disposal.

In view of the present shortage of materials the publication should be of great interest to manufacturers throughout the country.

The General Electric Review (U.S.A.)

THE *General Electric Review* (*U.S.A.*) for August, 1919, contains several articles of topical interest. The serial articles on "Method for More Efficiently Using our Fuel Resources," and on the work of the General Electric Co. of the United States during the war are continued. There is also an interesting communication by Major O. F. Allen on Army Electrical Work in the Advance Areas of France. The account of the work of the General Electric Co. refers to several problems, such as the design of searchlights, signalling lamps, etc., illustrating the applications of light in the war.

THE INDUSTRIAL LEAGUE AND COUNCIL.

THE Industrial Reconstruction Council and the Industrial League, who are amalgamating under the above title, have arranged for a series of fortnightly conferences dealing with the working of Whitley Councils set up in the Road Transport, Silk, Wool, and Allied Textiles, Pottery, Building, and Gloves. The first of these conferences was arranged for Sept. 30th, in the Hall of the Institute of Journalists. A similar series of Scientific Management is taking place in the same hall on Wednesdays at 5.30 p.m., commencing on Oct. 8th, while fortnightly lectures at the Guildhall on Industrial Problems take place at 4.30 p.m., starting Oct. 7th. Admission to the conferences is free (no tickets being necessary); tickets for the Guildhall lectures can be had on application to the Secretary, Industrial League and Council, 66, Victoria Street, S.W.1.

CAREERS FOR EX-SERVICE MEN.

ONE of the most important features of the measures for re-settling ex-service men in civil life is the Government scheme whereby ex-officers and other ranks of good education may be assisted to take up or resume training for business and professional careers. In the phase of the work dealt with by the Appointments Department of the Ministry of Labour, training is arranged for in offices and work, etc., and the co-operation of employers is therefore essential to success. Many employers have responded to the appeal which has been made to them with the greatest willingness, and although the scheme has only been working fully for a comparatively short time, over 3,500 students are now in training. Engineering is a profession which is greatly sought by candidates, and at 22nd August there were 602 students training in the various branches of the profession. The number of applicants is, however, very greatly in excess of the number of training vacancies available, and employers who can help by offering to train suitable candidates are urgently requested to communicate with the nearest district office of the Appointments Department. It should be added that, in cases where it is proved necessary, grants are made to students to assist in payment of their fees and maintenance during the period of training.

JOINT INDUSTRIAL COUNCIL FOR THE ELECTRIC CABLE INDUSTRY.

THE Ministry of Labour makes the following announcement:—

The first meeting of the Joint Industrial Council for the Electric Cable Making Industry was held at the Ministry of Labour on Thursday, 4th September. Mr. Bortram Wilson, of the Ministry of Labour, who presided, during the earlier part of the proceedings, pointed out that this was the forty-fifth Joint Industrial Council to be formed.

Mr. L. B. Atkinson, Cable Makers' Association, was elected Chairman and Mr. A. Allison, of the India Rubber, Cable and Asbestos Workers' Union, Vice-Chairman, and the following were appointed as Joint Secretaries:—For the employers' side, Mr. H. Standring (Messrs. Frankenburg & Sons, Limited); for the employees' side, Mr. H. McCale (Workers' Union).

ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

Publicity for Scientific Knowledge.

In referring to the second British Scientific Products Exhibition in August last we remarked that the future history of this country in the scientific field depends mainly on the cultivation of an enlightened public opinion. The war has undoubtedly led people to appraise more justly the direct material benefits of applying science to industry. But it is important that they should also know something of the processes leading to inventions and discoveries, that they should recognise that quick results cannot always be guaranteed, and above all that it is impossible to predict the ultimate utility of much of the scientific knowledge so laboriously acquired. We have had many instances lately of unforeseen important applications of purely scientific investigations. Among these may be mentioned the application of the rare gas helium for the envelopes of airships, of the rare gas argon in the bulbs of gas-filled incandescent lamps, and of the rare gas neon in tubes used for wireless work, as well as the tubular lamps for lighting invented by Mons. G. Claude. When these gases were discovered in minute quantities as constituents of the earth's atmosphere, nothing appeared more unlikely than that they would find practical applications of this kind. So it has been with many other scientific discoveries.

During the last few weeks we have had another instance of a great discovery in the field of pure science, and although here again the immediate practical effect may be imperceptible as yet, it is quite possible that the new light thus shed upon scientific principles will indirectly affect the progress of applied science in countless directions in the future. The event to which we refer is the announcement of the Astronomer Royal, following the observations during the eclipse of May last, that the rays of light from certain distant stars were proved to be appreciably bent during their passage close to the sun. It was only during an eclipse that these stars, apparently closely contiguous to the sun, could be clearly observed, and a small but appreciable displacement in their position showed that the light-rays had been diverted in the manner described. The importance of this lies in the deduction that the light-rays so diverted by the gravitation of the sun must have possessed *weight*—in other words that light is not merely a manifestation of energy, conveyed through imponderable ether, but is essentially material. What lends the discovery special interest is that the actual displacement was calculated beforehand by the Swiss physicist Einstein, and has proved to be closely in accord with his theories. It would thus appear as though scientists are being driven to abandon, or rather to modify, the wave-theory of light which has held its ground for more than a century, and revert to something approaching Newton's corpuscular theory.

The importance of all this from the physical standpoint will be readily grasped by anyone familiar with the study of light. But there are other deductions of even wider significance from the philosophical standpoint, though scarcely to be grasped except by the advanced physicist and mathematician. Briefly these considerations arise from the fact that our observations of time and space are ultimately derived from the study of light received from very distant celestial objects, and that accordingly new influences hitherto ignored must now be considered. From this standpoint space is no longer to be regarded as a fixed unalterable thing, and its apparent characteristics depend on the matter passing through it ; space and time are relative terms, bound up with one another.

Into these abstruse reflections we cannot enter deeply. We only mention this event because of its immense scientific import, and as an instance of an advance in scientific knowledge which has no immediate material application, and yet may be destined to influence profoundly future research, and thus open out new fields of knowledge whose influence is incalculable. It is good that public attention should be drawn to such advances in knowledge, and that people may realise that such discoveries do not invalidate previous knowledge, but rather show it in a new aspect ; the existing structure of knowledge is not demolished but merely extended.

We have always held that it is desirable not only to foster public appreciation of the direct material benefits of applied science, but to lead people to recognise the far-reaching scope of great scientific discoveries and to regard the whole subject on broad lines. We are therefore interested to observe that a new monthly journal is to be established as the result of a conference called by the joint invitation of the President of the Royal Society and the President of the British Academy, under the title of *Discovery*. The journal will aim at presenting in a popular form the progress of knowledge in all its branches. The journal will be under the control of an influential trust, and will be under the management of a committee representative of the bodies forming the Conjoint Board of Scientific Societies. Besides fulfilling its primary aim of conveying knowledge to the public, the journal should be the means of bringing representatives of various fields of knowledge into closer relations, and we wish it every success.

The Gas-filled Lamp and the Lighting of Exhibitions.

During the last few months several important exhibitions have been held in London, and, with the removal of war restrictions, we may expect them to become a regular feature, as in pre-war days. We should therefore like to draw attention to one matter that has scarcely received the attention it deserves—the proper lighting of the exhibits. Although the attendance during the day-time has been considerable, it is naturally in the evenings that most people take the opportunity to visit exhibitions. Professional and business men are naturally occupied in the daytime, and in general it is chiefly those who have some direct vocational interest in the exhibits who can attend in the daytime. Moreover, during the winter months artificial lighting is probably required during a great part of the day.

It is therefore surely a matter of importance that the exhibits should be well lighted and easily seen. An exhibition stall, like a shop window, depends very greatly on its lighting arrangements for attracting public attention. Unscreened bright lights placed at the eye-level among the contents of the stall discourage closer inspection, and in no wise attract visitors, and the results of spending several hours amongst rows of stalls lighted in such a manner are a sense of weariness and headache. The importance of screening these bright lights, of adopting the motto "light on the object not in the eye," is the greater because gas-filled lamps, with their greater intrinsic brilliancy, are coming into general use. In the streets the exhibition of unscreened lamps of this type in shop windows is already a nuisance, though the shopkeeper might urge in his defence the present difficulty in getting adequate supplies of some types of reflectors—a difficulty which we believe will be eliminated in course of time. But in the case of an exhibition, where each stall is specially constructed, there is surely no excuse for the display of unscreened lamps. It ought to be possible, by forethought, to secure the necessary shades and reflectors for a temporary occasion such as this ; and even if there is difficulty in securing adequate supplies of shades and reflectors, it is an easy matter to design the stall so that the lamps can be concealed behind façades, signs, etc., so that their direct rays are not received by visitors.

Another point that deserves consideration is that the use of glaring unscreened lamps by some exhibitors is prejudicial to others. Even a well-lighted stall, with lamps properly screened, may be "killed" by adjacent glaring lights. Seeing that every exhibitor is entitled to get the full benefit of the space allotted to him he ought not to be penalised in this way. For the sake of exhibitors as well as the general public, we think that some uniformity of procedure in regard to lighting in exhibitions ought to be adopted. As the whole arrangements are usually in the hands of one or two appointed contractors it should not be difficult to devise a few rules of procedure which would prevent fundamental principles of lighting being violated, at the same time leaving scope for justifiable ingenuity by individual exhibitors in securing striking lighting effects. Any such special devices should, however, be supplementary to the main lighting, and speaking generally, it seems desirable for an exhibition to be lighted on a fairly uniform plan. As an instance, we may recall the uniform diffused semi-indirect lighting installed in the Dutch Shipping section at the recent Engineering Shipping and Machinery Exhibition, which was generally considered to be well-devised for displaying this special series of exhibits.

The Lighting of the Interiors of Cinema Halls.

During recent years the lighting of the interiors of cinema halls has been the subject of much discussion. In some cases methods have been adopted which, both for practical convenience and artistic effect, mark a great advance over those usual in the past. There are certain principles which are now generally accepted amongst experts in this field—for example, that there should be no unscreened brilliant lights visible in the auditorium, such as are liable to produce a distracting effect on the eyes—whilst the films are shown on the screen. Concealed methods of lighting are thus becoming usual, but there is ample scope for ingenuity in contriving these methods so as to produce an agreeable and pleasing effect. A cinema hall, like a theatre, is in general only used by artificial light, and the illumination accordingly deserves very careful study. Success in this respect depends to a considerable extent on the forethought that is exercised in planning the architectural features with a view to these special methods of lighting. Another point that has been raised is the "grading" of the illumination, as visitors proceed from the brightly lighted entrance to the dimly lit hall, so as to make the transition gradual and allow time for the eye to adapt itself to the changing conditions.

We have recently received from Messrs. Vaughan and Mayer, of Milwaukee, U.S.A., particulars of some interesting installations made under their supervision, which illustrates these points. Among the installations described is the Delft Theatre at Escaban, Mich., U.S.A., which was recently the subject of an article in the *Electrical World*.

The feature of this installation is the use of "artificial windows" in the ceiling, *i.e.*, panels of diffusing glass behind which lamps are situated, the windows being so designed that the illumination gradually increases from a very low value in the front of the hall near the screen, to a higher value at the back, where it is chiefly necessary to aid the attendants, and where it has relatively little influence on the screen. In another theatre described three alternative systems of lighting are provided, a low intensity yellow light used during the period when pictures are being shown, a low intensity blue light employed for moonlight effects, and a higher intensity white light used between performances. An interesting item of information relating to this installation is the presentation of a chart showing the gradual diminution in the value of illumination provided which exceeds 8 foot-candles at the entrance of the theatre, drops to over 1 foot-candle in the lobby, and amounts to about 0·2 foot-candle under the balcony at the back of the theatre. From this point to the front of the theatre it falls gradually to a very low illumination.

The complete suppression of all exposed bright lights, such as are trying to vision, seems a good feature in these installations, and the manner in which the artificial lighting in the theatre is so distributed as not to interfere with the effect on the screen deserves special notice. The fact that it is possible to provide as much as 0·2 foot-candles at the back of the theatre, and 0·1 foot-candles mid-way between screen and the back, without apparent prejudice to the showing of films, is of special interest.

Further corroborative evidence seems desirable on this point, but the results so far obtained are of considerable interest.

LEON GASTER.

THE JAPANESE SPECIFICATION FOR TUNGSTEN INCANDESCENT ELECTRIC LAMPS,

It will be recalled that in the particulars recently given of the Japanese Illuminating Engineering Society, it was mentioned that a Standard Specification for Vacuum Tungsten Incandescent Lamps had recently been completed, and that a similar specification for gas-filled lamps is in course of preparation. We have now received from the Society, through Mr. M. Uchisaka, who has been on a visit to the Electrotechnical Congress in this country, a copy of the former specification, which presents some points of interest. It is to be noted that the specification was prepared by a special committee appointed by the Japanese Illuminating Engineering Society and the Japanese Electrotechnical Committee, by whom the specification has been approved and recommended to the Minister of Communications in charge of the supervision of electrical undertakings in general.

The specification is divided into three sections, dealing respectively with Rating, Construction, and Tests.

I. Rating.—In this section it is specified that the size of lamps shall be expressed by the total consumption in watts and that lamps shall be arranged in two classes, A and B, for which the normal life at the standard voltage is to be respectively 1,600 and 1,000 hours. It is especially worthy of notice that Japan (we believe alone amongst civilised countries) has succeeded in establishing a standard pressure for lamps, namely, 100 volts. The life of a lamp is expressed by the number of hours burned until the candlepower has decreased by 20 per cent. from its initial value. (The term " useful life " is discarded, because in many cases lamps should not be regarded as " useless" after this diminution in candlepower has occurred).

The size of lamps and the nominal candlepower (*i.e.*, mean horizontal candlepower marked on bulb) are as follows :—

Size in Watts	Nominal candlepower.
(7·5)	(5)
10	8
(12·5)	(10)
20	16
(25)	(20)
30	25
40	35
60	55
80	80
100	100

(Ratings indicated by figures enclosed in brackets are included in the schedule for the time being, but their discontinuation is recommended.)

II. Construction. This section follows familiar lines in specifying that lamps shall be of good quality and free from defects, that filaments shall be of uniform quality symmetrically disposed in the bulbs, that leading in wires shall be securely attached and that in their attachment no corrosive agents shall be used. The dimensions of caps (Edison Screw) are prescribed in detail and illustrated by dimensioned sketches. Similarly bulbs are divided into two classes, " nasu-gata " (straight-sided) and " maru-gata " (round) and the dimensions for the ratings indicated above are accurately stated, and illustrated by dimensioned sketches.

The following particulars are to be marked on the bulb :—

(A) The mark Ⓐ or Ⓑ, with the significance mentioned above.

(B) The voltage, watts and nominal candlepower (the latter only when requested).

(C) The manufacturer's mark.

(D) The purchaser's mark (if so requested).

III. Tests. Tests are to be made on lamps selected at random from the whole batch of a given size and class. Tests on selected lamps proceed in the following order : (A) Inspection of construction ;

(B) watt consumption test; (C) photometric test; (D) life test. The quantity of lamps selected shall be 5 per cent. of the whole consignment and in no case less than 10 lamps. If lamps are inspected at the factory 80 per cent., and if the inspection is done elsewhere 70 per cent. of lamps must comply with the requirements. Limits are assigned for the permissible variation in diameter of cap at top and bottom of thread, the tolerance amounting to 0·15 mm.; for other parts variation in size must be within 0·5 mm.

Total watts consumed are measured on each of the selected lamps and mean spherical candlepower is measured at the marked voltage after they have attained constant value in burning. Candlepower may be measured either by direct measurement of mean spherical candlepower or by measurement of mean hor. candlepower, provided that the spherical reduction factor is known.

The allowable limits of variation are as follows, the percentage of lamps to comply with requirements being as stated above :—

Size of Lamp.	Permissible variation for total consumption in Watts.	Permissible variation for mean spherical candlepower.
7·5—10 watts	± 10 per cent. of standard	0·8 candle-power
Over 12·5 watts	± 7·5 per cent. of standard	13 per cent. of standard

The rated candlepower shall be in accordance with the following schedule, or shall have a higher value if specially stipulated :—

	Rated candlepower.	
Size ot Lamps.	A Class Lamps.	B Class Lamps.
7·5	3·5	4·3
10·0	5·8	6·2
12·5	7·3	7·8
20·0	12·5	13·1
25·0	15·6	16·5
30·0	19·5	21·1
40·0	26·5	28·9
60·0	41·0	44·5
80·0	58·5	62·4
100·0	74·1	70·8

The quantity of lamps subjected to the life test shall be 1 per cent. or more of the selected lamps and in no case less than five lamps. The average life of all the tested lamps and the individual life of 4 per cent. or more of the tested lamps shall be over 1,600 hours in A class lamps, and over 1,000 hours in B class lamps. The test may be made at a higher voltage than the marked voltage when the relation between voltage and life is agreed upon in advance.

Explanation of the Specification.—An appendix to the specification proper contains a useful explanation of the circumstances leading to its adoption and determining the nature of the tests. It is remarked that the recent expansion of the lighting service in Japan has led to the establishment of many lamp manufacturing companies, and there has been hitherto a lack of uniformity in production. The recent introduction of lamps having filaments of various shapes, especially the gas-filled lamps, led to the decision that the lamp rating should in general be based on the energy consumption. Yet as most of the electric lighting companies in Japan are using the flat rate system based on mean horizontal candlepower, it appeared desirable to provide for the continuation of the marking of this value on the bulbs of lamps, on request. In view of the wide prevalence of the flat rate system, it was desirable to pay special attention to the standardisation of life. The life of 1,600 hours is regarded as the normal condition; but in circumstances where the cost of electricity has risen or its scarcity has become felt, the life of lamps is preferably fixed at 1,000 hours. The designation of these two classes of lamps by the letters A and B is in accordance with practice in Switzerland.

As regards the standardisation of lamp bases it is remarked that there is at present undue variation in different parts of the country. For example, the products of the Mansai districts are generally small, and those from Tokyo and its vicinity relatively large. Fortunately, as a result of exhaustive tests of lamp bases and sockets supplied by many lamp-manufacturing companies, it appeared that in general only 3 per cent. fell without the assigned limits. The bayonet cap is omitted from the present regulations as it has only a very limited use in Japan. The adoption of the circle surrounding the letters A or B will be a convenience as indicating that lamps are made in accordance with the specification.

The Committee has adopted as the best practice the direct measurement of mean spherical candlepower by means of the Globe photometer. But if this apparatus cannot be obtained, the candlepower may be determined by the spherical reduction factor, after measuring mean horizontal candlepower. The rated candlepower must be clearly discriminated from the marked candlepower, the former being the mean spherical candlepower and the criterion determining whether the lamps pass with the photometric test; the latter merely the figure nearest to the mean horizontal candlepower, adopted for the convenience of the flat rate system and marked on the lamp. Thus the marked candlepower is a figure essential to the lighting business while the rated candlepower is one essential to lamp transactions.

SWITCHING REQUIREMENTS IN LARGE BUILDINGS.

In these times of economy the vital importance of adequate switching appliances in large buildings ought surely not to require emphasis, especially in those cases where a large area is subdivided, and it frequently happens that only a small section is in use, possibly owing to a small proportion of the staff working overtime. It is to be feared that during the war a considerable number of hastily erected and equipped buildings were not sufficiently provided for in this respect, but an incident recorded by a writer in the *Daily Express* must surely be an extreme case. The building in question was a large shed, situated in the London Docks, hundreds of feet long and containing a very large number of vats and puncheons of spirits. Prior to the war, owing to the need for rigid precautions against fire, no artificial light was provided (the authorities, it is remarked, having apparently never heard of electricity), and all work ceased at dusk.

In 1914 the Army authorities took over the building for the supply of rum to the troops, and as spirits were needed at all hours some form of artificial light became necessary. Electric lighting was accordingly introduced on a lavish scale, but in one curious respect economy was exercised —a single switch was regarded as sufficient for the whole system. When the Army control was removed it was at first proposed to remove the lights, but enterprise prevailed and the innovation remained. So, too, did the single controlling switch which lights up the whole building when only a corner is visited, and the handful of clerks in an adjoining office cannot finish their work in the evenings without bringing thousands of candlepower to bear on the gambols of the survivors of rat-week.

LIGHTING RESTRICTIONS IN PARIS.

We notice that some concern has been caused to places of entertainment in Paris by the renewal of the regulations restricting the external lighting of theatres, cinemas, etc., in the interests of fuel saving. The proprietors of such places depend mainly on the night-attendance, and they are now petitioning the Prefect to achieve the desired economy by diminishing the hours instead of restricting the lighting. They would prefer to adopt the war-procedure of closing cafés, etc., at midnight, instead of reverting to the pre-war hour of 1 a.m. Apparently the public, after issuing from the theatres usually stay less than an hour at the cafés and the attendance during the period 12 p.m. to 1 a.m. is not large.

FREE MAINTENANCE OF GAS BURNERS.

In his recent presidential address before the North of England Gas Managers' Association, Mr. H. E. Bloor emphasised the importance of the lighting section of the demand for gas. The lighting load, he said, with its regular seasonal rise and fall with the lighting hours, played a most important part in the economics of gas lighting, and could never be replaced by a purely heating load. In order to maintain this business it was essential to attend carefully to such matters as pressure and uniform quality of gas, and it might be necessary to adopt free maintenance. More lighting business had been lost because of defective burners than for any reason.

STREET LIGHTING AND TRAFFIC ACCIDENTS.*

By Ward Harrison.

There are few available data showing how many of the accidents in city streets are due to inadequate lighting, and the results of a survey of 3,549 traffic accidents, shown by the records of the Police Department of the city of Cleveland, U.S.A., for a period of one year are therefore of great interest.

The purpose of the survey was to determine how many of the 1,059 accidents which occurred after dark would have been avoided if daylight, or its equivalent, had been available. The records show that between 5 and 9 p.m. there were 157 accidents in June and July, and 193, or 22 per cent., more, in December and January. The number of accidents was thus 22 per cent. greater in the darker winter months.

There are, however, other variables besides the question of daylight and darkness. For example, there are less vehicles in the streets in mid-winter; hence less liability to accident; this however, is partly counterbalanced by the effect of slippery pavements. We can find the effect of all these other factors, except lighting, by comparing the number of accidents which occur during the middle of the day in winter months with those occurring in the same period in summer months. The records show that for December and January there were 12½ per cent. less accidents between 9 a.m. and 4 p.m. than occurred during the same period in June and July. It also appears that there were 8½ per cent. less accidents for the winter months during the hours that were dark at *both* seasons, *i.e.*, from 10 p.m. to 5 a.m. Therefore, except for the question of light, there would have been fewer accidents between 5 and 9 p.m. in the winter months than for the corresponding summer months. Actually, instead of 193 accidents in winter for every 157 accidents in summer, there would have been 140 accidents in the winter, had it not been for the lack of daylight. There were thus 53 accidents, which can be attributed directly to loss of light. If we apply the same proportion (*i.e.*, the ratio of 53 to 193) to the total number of accidents occurring after dark in Cleveland for the whole year, we find that 292 of them are to be attributed to lack of light, and of these at least 14 must be classed as fatal accidents.

It is also interesting to compare the accident statistics for the White Way district of the city (which is exceptionally strongly lighted) with those occurring in other areas. The number of accidents in the White Way district is so small that the results can only be taken as indicative, but it is interesting to note that in this district there were 21 accidents in winter between 5 and 9 p.m., and 20 in the summer; whereas in the whole city the proportion would have indicated 25 accidents in winter for every 20 in summer. We are safe in saying, therefore, that the higher intensity in the White Way has a marked tendency to reduce the number of accidents.

---

* Abstract of an article in the *Electrical Review* (*U.S.A.*).

RECENT DEVELOPMENTS IN PUBLIC AND PRIVATE LIGHTING.

By W. C. Clinton,
Assist. Professor of Electrical Engineering at University College, London.

(Abstract of a Public Lecture delivered at University College, London, at 5 p.m. on October 24th, 1919.)

The last decade has seen the introduction to general use all over the world of a number of new and more efficient sources of light. The development and exploitation of these has been particularly rapid in America, where effort in this direction was very much less impeded in the last half of this period by war conditions than in Europe. Yet, although these conditions retarded the use and development of new methods of producing light, the necessity that compelled us to screen and reduce all lighting was the means of demonstrating that immediately before the war, an immense amount of artificial light was wastefully and injuriously used. With the gradual removal of legal and economic restrictions there is now a distinct tendency to revert to lavish misuse of artificial light.

The object in view on this occasion is to give a statement of the principles involved in the improvement of existing light sources, or in the production of new ones, and to point out the best ways of making use of them, having regard to both efficiency and convenience. It must be remembered that the sensation of light is a subjective phenomenon and is produced by the entry into the eye of vibrations taking place at certain definite rates. These vibrations are themselves the result of vibrations of particles in the source of light. The production and maintenance of any kind of vibration in a material body requires the continuous expenditure of energy on it, from which it follows that the most efficient production of light would ensue if only those vibrations which effect the eye were created. This is the principle which has to be kept in mind when seeking for more efficient sources of light or when attempting to improve the efficiency of those already known.

Self-luminous flames obtained by burning gas or oil in air are the oldest sources of artificial light. They derive their luminosity from the presence of small solid particles of carbon raised to a high temperature. The emission of light in proportion to heat is greater with substances like carbon, the higher the temperature to which the substance is raised, and this proportion is a maximum for a temperature of about 6,000° C.—roughly the temperature of the sun. It has not been possible hitherto even to approach this temperature by any human device, so that for practical purposes it may be said that the higher the temperature to which a solid body like carbon can be raised, the better it becomes as a source of light. This ruling does not, however, apply to all bodies when heated. Certain solids and all gases can be made to give out light of definite rates of vibration in relatively great quantity at temperatures which can be easily reached either by the direct application of heat as with a gas mantle, or by electric current, as in the flame arc, or the mercury arc. Increased efficiencies have been reached with self-luminous flames by simply increasing the flame temperature, while at the same time ensuring that the decomposition of the combustible in the flame is slow enough to allow of the presence there in sufficient quantity of fine particles of carbon. Beginning with the candle, a higher temperature is realised with enriched coal gas, pre-heated and burnt from a flat flame burner (albo-carbon light), and this temperature is again much exceeded in the acetylene flame.

Electric incandescent lamps have been improved as sources of light, in the same way. For many years carbon was the most suitable material available for filaments, and much research was successfully directed to raising the limit of temperature which carbon filaments would withstand in a vacuum without too rapid disintegration. A great step forward was made when it became commercially possible to draw down the highly infusible metal tungsten into fine wires. It was found that in a good vacuum this material would stand a working temperature much in excess of that attained in the best carbon filament lamp, and giving at least double the luminous efficiency. A further increase in the efficiency of the tungsten wire lamp has been attained by filling the bulb with a chemically inert atmosphere of nitrogen or argon. This increases the facilities for dissipation of heat from the filament, and by altering its configuration from a straight wire to a fine spiral, the final temperature of the filament, at which the rate of heat-production is equal to the rate of heat-dissipation can be again raised, resulting in a further increase of luminous efficiency by nearly 100 per cent.

A mixture of thoria with a small quantity of ceria is still the best preparation for the impregnation of gas mantles. Attention has been devoted to the production of an improved mantle woven from artificial silk—a material made in the same way as that finally used in the manufacture of carbon filaments for electric incandescent lamps. A flexible mantle is thus produced, with the impregnating mixture thoroughly incorporated with it, and is capable of withstanding the higher temperature associated with the use of high pressure gas better than mantles woven from cotton thread or ramie fibre. The use of gas at a pressure three or four times greater than that usually supplied increases the velocity of out-flow of the combustible mixture from the burner, and if the proportions of gas and air have been adjusted to give a steady flame (*i.e.*, if the flame velocity is equal to the velocity of out-flow) a much larger mantle can be successfully heated to the temperature required for luminescence. A larger source of any kind is more efficient *per se* than a small one.

The source with the highest luminous efficiency still remains the flame arc lamp, an electrical method of producing selective radiation. Minor improvements in design have been effected in it with the object of making the lamp of more use commercially, such as the use of magazines for reducing trimming charges, and the provision of adequate ventilation for preserving the enclosing glass envelope free from opaque deposit. The distinctive selective radiation produced by the electric arc in mercury vapour has a high luminous efficiency but is limited in its applications by the restricted range of vibrations produced.

The newer sources of light, viz., the high-pressure gas lamp in large units, the flame arc lamp, the mercury vapour lamp, and the gas-filled tungsten lamp, enable light to be produced in very large quantities much more cheaply than formerly. It follows that the necessity for conserving light imposed by relatively dear production from small units is now not so pressing as it once was, thus making it possible to lay out lighting schemes on lines approximating more closely to what is regarded as ideal. Yet artificial light is still relatively difficult to produce, and easy to misuse, and this should be remembered in the design of every lighting scheme.

The most important factor to consider in any such scheme is the human eye. Every installation is judged by that in the end, and not by photometric readings, although these may be very helpful. The eye is sensitive to, and apt to be injured by, excessive contrasts in illumination in close proximity, effects which are only too easily obtained by the careless use of modern light sources of high intrinsic brilliancy. In all good lighting, glare must, therefore, be avoided. Too great uniformity of illumination, however, is dull and may lead to confusion of outline. Things are only seen by the difference of illumination of their parts, combined with differences of colour. An absolutely even illumination of a monochromatic object and background would render it impossible to tell one from the other.

Three broad classifications of systems of lighting have now come to be generally recognised: Direct, Indirect, and Semi-indirect. With direct lighting, the major part of the illumination on the working plane is provided directly by the source with or without a shade above it. High intensity sources should be screened or shaded in the line of direct vision. By the use of properly proportioned shades very useful redistribution of the light can be effected.

In using the polar curves now commonly supplied with most sources, it should be remembered that the shape of the curve is a guide to the direction in which the intensity is greatest or smallest, but its size is no guide at all to the total quantity of light emitted.

Street lighting is effected by direct methods, including those cases in which a diffusing globe around the primary sources acts as a secondary source of light. The problem to be solved in lighting a street successfully, is nearly always different from that presented in the lighting of an enclosed space. They approximate in character only in the case of the busiest streets. The type of source to be preferred is one that naturally sends out the greater part of its light not very far below the horizontal, in order to secure as much light as possible at the point of minimum illumination, half way between two standards. The plain carbon arc with upright carbons on a direct current circuit has an advantage in this respect, and so too has the vacuum lamp with metal filament, approximating an upright luminous cylinder. The horizontal flame arc, and inverted gas mantle lamps, give too much of their light in a downward direction, unless for close spacing of standards, and require a refractor to redistribute the light. Refractors of this kind have also been found necessary with long distances between the standards when gas-filled electric incandescent lamps have been used. Where standards can be placed close together and for the creation of effect, this type of lamp in diffusing globes is successful. The best street lighting is obtained with powerful units put up as high as possible above the street, so as to make the ratio of this height to the distance apart of the standards, which is in any case less than unity, as near to that as possible. The use of high standards is also advantageous in minimising glare by removing the sources from the normal line of vision.

For purposes of effect in public lighting, the results achieved by outline lighting with innumerable small specks of light arranged along the chief architectural lines of a building can now be surpassed, without fixing anything on the building at all, by "flood lighting."

Large gas-filled lamps are placed in projectors which can be adjusted so as to give beams of very various angles of divergence. These projectors are suitably placed at points near the building to be illuminated, which can then be flooded with light. When properly done very striking effects can be obtained.

It is with indoor lighting that indirect and semi-indirect lighting can properly be made use of. With indirect lighting, the whole of the illumination on the working plane is due to light reflected from a very large surface, the ceiling and walls of the room. In this way, there is no possibility of glare, but there is a danger of an impression of sameness due to the almost total suppression of shadows. The semi-indirect method still uses the ceiling and walls as reflectors for most of the light arriving at the working plane, but the reflector under the lamp is made of translucent material, so as to let through some light. This should not be so much as to make the bowl appear too bright against the background. Although the adoption of these two methods means some loss of light even in the best of such installations, yet if light can be produced cheaply enough and in sufficient quantity, it becomes good practice to incur this loss, the results not being obtainable in any other way in the present state of the art.

One may perhaps suggest that in all lighting, one object to be aimed at is that of rendering lighting fittings and fixtures an inconspicuous as possible by daylight. The enormous candelabra or chandeliers of the part are gradually disappearing, and with the advent of more perfect light sources than those we possess to-day, we may hope to progress still further in the direction indicated.

THE LIGHTING OF INTERIORS OF CINEMA HALLS.

A PROBLEM that has recently excited much interest is the provision of sufficient artificial illumination in cinema theatres to enable the audience to find their way about and yet not to prejudice the appearance of the picture on the screen. Assuming that the clearness and definition of this picture is not appreciably affected, the diminution in contrast between the brightness of the screen and the relatively dark theatre would be an advantage. One step that may be taken is to provide a somewhat higher illumination at the back of the theatre, most remote from the screen, where people are entering and where light is most needed. This also serves the purpose of graduating the change in lighting conditions so that the eye may become adapted to the surroundings as the persons pass to the area of greater darkness nearer the screen.

These problems are mentioned in a recent article in the *Electrical World*,* which emphasises the desirability of directing such artificial light, as much as possible, on the seats of the theatre and not on the walls whence it is apt to be reflected on to the screen. Another point mentioned is the necessity of avoiding any bracket lights or other sources placed round the theatre which are distracting to the eye and interfere with comfortable vision. An interesting example of the planning of an installation on these lines is given. At the Delft Theatre (Escanaba, Mich.) the lighting is effected solely by means of artificial

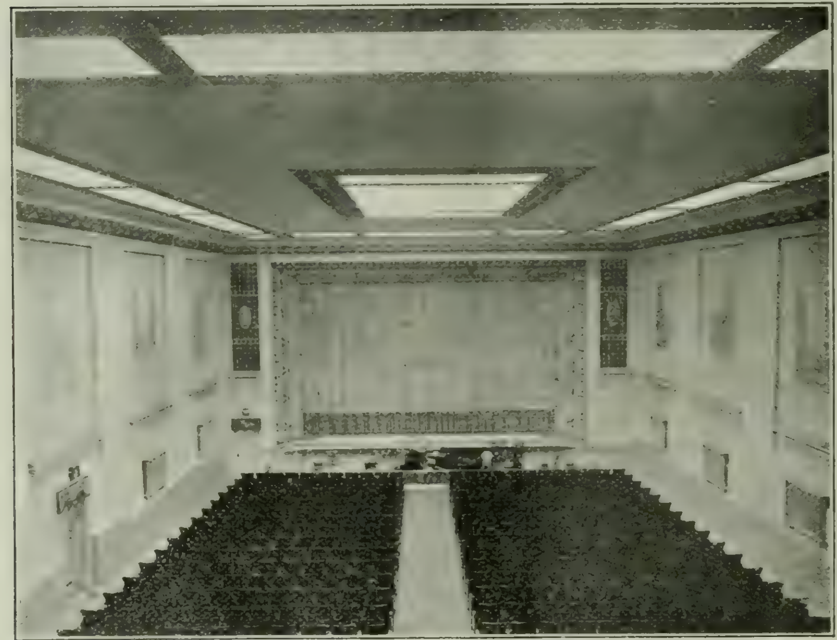


FIG.1.—Showing special method of illuminating the Delft Theatre, Escabana, Mich., U.S.A., by means of glass panels in the roof. This device enables a low illumination to be provided while the performance is in progress.

---

* May 17th, 1919.

windows in the ceiling. Above these windows are long boxes, approximately 18 inches in height, painted white inside. The windows are covered with light diffusing glass. The lamps are arranged on three circuits allowing full illumination, a lower value, and a lower value still for use when the photo-plays are being shown. The installation is also so designed that most of the light falls in the aisles and stalls, a very low value of illumination being provided near the screen and a higher value in the rear.

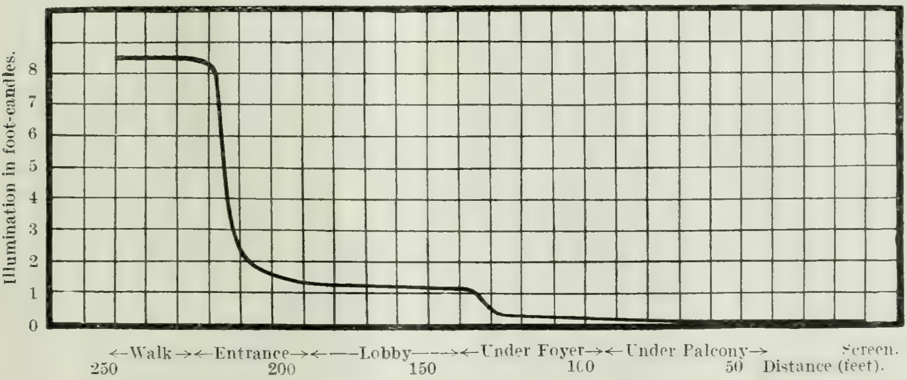


FIG. 2.—Variation in illumination throughout Merrill Theatre in Chicago.

We are indebted to Messrs. Vaughan and Mayer, consulting engineers, of Milwaukee, who designed this installation, for the accompanying photograph. Our attention has also been drawn to an interesting analysis of conditions in cinema theatres by Mr. L. W. McOmber,* who described another cinema theatre in Milwaukee that has features of interest. In the Merrill Theatre special attention was given to the general lighting with a view to affording a suitable transition in brightness in passing along the lobby, foyer and down to the front of the auditorium. In this way the eye becomes accustomed to the darkened surroundings gradually. The long lobby in this theatre was of special assistance, as it permits a gradually diminishing illumination. The lighting of the lobby was on the cornice principle, while in the waiting rooms indirect lighting is employed. The balcony is lighted by skylights on a plan similar to that shown in the above illustration. For the main part of the auditorium a modified form of cove lighting is used. An interesting feature is the use of three alternative systems of lighting, (1) a low intensity yellow or white light used during projection of pictures, (2) a low intensity blue light used while moonlight effects are being shown, and (3) a higher intensity white-light used between performances or for lighting the auditorium in the ordinary way when it is being cleaned. A chart is presented showing the gradual diminution in illumination, which attains 8 foot-candles near the entrance of the theatre, drops to about 2 foot-candles at the entrance to the lobby, and subsequently to slightly over 1 foot-candle at its extremity; then falls rapidly to about 0·2 foot-candle under the balcony at back of theatre, gradually falling to zero at the front of the auditorium where the screen is located. The exterior spectacular lighting of the theatre was also the subject of special study, the coloured lights used at the entrance being gradually altered in colour according to a predetermined cycle. The entrance is lighted by indirect methods, six units with glass panels of different colours being employed. A feature of the interior lighting is that all exposure of bright lights liable to dazzle the eyes are completely avoided.

---

* *Electrical World*, July 15th and 22nd, 1916.

THE LIGHTING OF SUBWAYS AND UNDERGROUND PASSAGES.*

The lighting of subways and underground passages presents special difficulties, one of these being the fact that space is limited and the height of suspension usually low. It is, therefore, difficult to place the lamps at a sufficient height to be out of the range of view of persons proceeding along the subway, and at the same time to secure the desired uniform illumination. Much depends on the design of the lighting simultaneously with the constructive features of the subway. In some cases it is possible to place the lights between beams on the ceiling so that they illuminate the floor, but are rendered invisible to people looking along the length of the subway. A good example of this form of dealing with the problem was given by Mr. A. Cunnington in his paper on railway lighting before the Illuminating Engineering Society in March this year.†

An interesting account has recently been given in the *Electrical World* by Messrs. Ward Harrison and E. A. Anderson of the methods employed in lighting the subways in conjunction with the new Cuyahoga River Bridge in Cleveland, Ohio. As it is expected that the city will soon need a complete underground car system to deal with its downtown traffic, it was particularly desired that the lighting of this subway should make a favourable impression and prepare the public mind for the proposed scheme of underground transportation.

The chief requirements are stated as follows :—

(1) Sufficient light to create a bright cheerful appearance.

(2) A large proportion of light directed at angles above the horizontal so as to provide good illumination of vertical surfaces, necessary for recognising people on platforms of stations, etc.

(3) Ample diffusion of light by ceilings, walls, and columns, avoiding shadows and a "tunnel-like" aspect.

(4) Light sources of low brilliancy so that they may be viewed directly without glare.

(5) All lighting units facing at right angles to the tracks, practically concealed from the view of motormen on approaching street cars.

These requirements were met by the aid of a special form of unit, which can be mounted flush with the ceiling, the wall, or the surface of columns. It consists of a box containing two 75 watt gas-filled lamps backed by porcelain enamelled reflectors and having in front of them a panel of opal glass. The front is hinged and swings open, enabling easy access to the lamps for maintenance and cleaning. The two lamps are on entirely independent circuits. The white tiled walls and light-tinted ceiling of the subways assist materially in diffusing the light, and as the sources are flush with the surrounding surfaces there is no obstruction to the view and glare is avoided. With 75 watt lamps an average illumination of 1⅓ foot-candles is obtained, but the size of the boxes is such that 200 watt lamps could be installed should it be desired to increase the illumination. Another advantage of having two lamps is that one circuit can be extinguished during hours when there is very little traffic. It is remarked that although all the fittings are within easy reach to facilitate cleaning only one glass plate has been broken during the five months that the lighting has been in operation, and there has been no case of theft of lamps. The good maintenance record is attributed largely to the fact that there are no lamps exposed, and no pendant lamps to tempt missiles.

Unfortunately the concrete work for the subway passenger station at the east end of the bridge was all in place before the lighting was considered, and it was therefore impossible to use the flush type of fitting described above. Instead a pendant unit was developed to give the same general results, similar diffusing glass plates being used for the sides of a lantern and an additional plate fitted in the bottom to give an increased downward component. The two-lamp system was adhered to and the effect was satisfactory, though not quite equal to that where flush units were installed. It is interesting to note that in the case of these pendant fittings several of the glass plates have been mischievously broken.

---

* Abstract of an article in the *Electrical World*.

† ILLUM. ENG., March, 1919.

In the car tunnel approaches it was necessary to provide sufficient illumination to enable the motormen to see any object on the track or any person who might inadvertently wander into the tunnel. It was also desired to illuminate the side walls strongly so as to remove any sense of " going into a dark hole." 60-watt lamps in bowl-type reflectors were accordingly mounted at the top of the tunnel directly over the car tracks. These cut off all direct light from the eyes of motormen and provide the requisite even illumination.

The system adopted of having circuits everywhere in duplicate, and supplied from entirely independent sources of power has proved of great value. On two occasions one of the circuits was interrupted but passengers were not seriously inconvenienced, as there was half the normal illumination remaining. In view of the dangerous possibilities of a total failure of light at a busy time when crowds of people assemble, this safety factor is of great importance.

On the roadway and side-walks of the upper level of the bridge the same general style of fitting, which is a continuation of the downtown series incandescent system, is employed. Octagonal lanterns fitting with diffusing glass panes are mounted on the top of pressed steel columns 15 ft. high, and lamps of 1500 candle-power supplied from individual transformers are used.

As an illustration of the advantage of good lighting in preventing public disorders and crime, it is mentioned that since the lighting system was introduced there has not been a single case of robbery or assault reported in these passenger stations since their completion.

SCIENTIFIC WAR-TIME PUBLIC LIGHTING IN PARIS.

We notice, in the account given in the *Gas World* of the recent visit of the Institution of Gas Engineers to France, an interesting reference to the measures adopted for the public lighting of Paris during the war. In the meter house at the Landy Gas Works in Paris visitors were shown copies of a large map of the city, representing studies of the public lighting question. The maps, mounted in sliding frames on a dark background, have small perforated holes made to represent the number of lamps to be lighted during the war. When any particular map was placed in position in front of a lantern the whole conditions of lighting of the city could be examined with a convenient bird's-eye view. For example, the difference in the effect produced by a map with 20,000 perforations as compared with that made by one with only 2,000 was very evident.

As a result of this method of study it was found that if the city was to be safely lighted it was quite a mistaken view to think that any part of a partially lighted city was more completely protected by being left entirely unlighted; for an unlighted area was so distinctly observable as being within the circle of the city that it was likely to be attractive to any airman seeking to bomb a vital part. The best protection was to put an equal measure of partial lighting all over the area under consideration.

ILLUMINATED POLICE IN BOSTON.

In the City of Boston (U.S.A.) a novel method of aiding the police in the control of traffic has been introduced. A red light is attached to the spike of the helmet and a white light on each shoulder, the lamps being supplied by a small portable battery carried on the back. The policeman also wears white gloves, which help to make him a conspicuous object easily distinguished amidst the traffic by night. The attention of drivers is thus readily drawn to the policeman's controlling arm, and the lights on helmet and shoulder help to prevent his being overlooked and run over.

ILLUMINATING ENGINEERING IN GERMANY.

We notice in *Licht und Lampe* an account of the proceedings at the sixth annual meeting of the German Illuminating Engineering Society on September 20th. Herr Geheimrath Strecker gave a summary of the proceedings of the various committees.

Courses of Lectures on Illumination.

Of chief interest is the announcement by Dr. L. Bloch that the Society has arranged for an elementary course of lectures on illuminating engineering, which it is hoped will be helpful to contractors, architects and others. The lectures are to take place from the middle of November onwards, a series of five or six addresses, each lasting 1½ hours being delivered. After dealing with fundamental principles of illumination the lectures will proceed to gas, electricity and other illuminants, and subsequently the arrangement of interior lighting and the design of lighting fittings will be discussed. The price fixed for the series is six marks for members, and 12 marks for non-members. The general nature of these lectures thus follows closely the lines adopted in the series arranged by the Illuminating Engineering Society in this country at various educational institutions in London a few years ago.

Glare and Contrast.

Dr. Lux made a communication on the deliberations of the committee dealing with glare and shadow-contrast. It was pointed out that such contrast in the available illumination have a double effect—there is the actual inequality of the illumination on the work and the distracting effect on the eye of successively viewing the brightly lighted parts, and the areas in comparative shadow It remains to be decided what degree of contrast should be permissible, and it was suggested that this might well form the subject of a dissertation for the Doctorate, or as a subject for a prize essay. As regards brightness, two limits were proposed, 0·75 H.K. per sq. cm. (apparently for objects in the direct field of vision) and 5 H.K. per sq. cm. for sources placed outside an angle of 30° to the normal direction of view. The former value is of about the same order as the brightness of a frosted vacuum tungsten lamp, the latter about the value for an unscreened incandescent mantle.

Lighting of a Large Hall.

Dr. Lux also gave an account of the lighting arrangements that has been tried in the large Philharmonic Hall, wherein thirty-six 35-candelpower vacuum lamps and two 1,000 watt gas-filled lamps were installed. This gave a total consumption of about 4 k.w. and the lighting was very uneven, variations from 7·5 to 80 lux being met with. Suitable reflectors were then introduced and the lights rearranged. Ultimately, the consumption was brought down to 2 k.w. and the variation in illumination was much less, namely, from 82·5 to 24 lux (approx. 3 : 1). However, the gas-filled lamps were considered to have a dazzling effect on the eyes of performers and it was found necessary to screen them with silk. The architect took exception to this arrangement and proposed glass prisms, which at the time were extremely dear. Further steps have been postponed for the present as the hall is in constant use. The discussion revealed a general agreement as to the difficulty of lighting such large rooms satisfactorily when the building has been completed and the importance of making provision for the lighting at an early stage in the design. Various other installations in which use was made of a diffusing glass ceiling, were mentioned with approval.

In connection with the formal business it was interesting to observe that the Council of the Society consists of 24 members, of whom six are to be members of the German Institution of Electrical Engineers (Verband Deutscher Elektrotechniker) and six members of the German Institution of Gas Engineers (Verein von Gas- und Wasserfachmännern).

THE USE OF HEAT AND ULTRA-VIOLET RADIATION IN THE WAR.

At the Washington meeting of the American Physical Society, held early in the present year, several very interesting communications were presented describing special applications of infra-red and ultra-violet rays, which are summarised in a recent issue of the *Physical Review*.*

Detection of Objects by means of Heat Rays.

The use of heat radiation, for the detection of invisible objects, formed the subject of a paper by Mr. S. O. Hoffman, Master Signal Electrician in the Science and Research Division, U.S.A. Trench warfare on the Western front, he remarks, was peculiarly a thing of night activities, as any movement was quickly detected by the enemy in the daytime. Early in 1918 work was started on the problem of detecting men and other objects at a higher temperature than their background by means of thermal radiation. The method only requires a receiving apparatus, the body studied furnishing the heat, and had the advantage that it is impossible for a man to know that he is under observation.

The apparatus consisted of a Hilger thermopile mounted in the focus of a 14-inch parabolic mirror, and connected with a d'Arsonval galvanometer. By this apparatus men were detected with ease at a distance of 600 feet. A man lying on the ground 400 feet away was detected unfailingly as soon as he showed the upper part of his face above ground. With some forms of apparatus it was even possible to distinguish between the painted and unpainted sides of a sheet of iron on fairly cloudless nights. At moderate distances a man could not cross the range of the apparatus without a marked indication being given. By merely ranging the instrument parallel to the front and about 30 yards in advance of the trenches raiders creeping into the lines by night could be detected. Naturally the time taken before a deflection was observed was of importance, but a pile was developed which gave maximum deflection in less than one second. The method was also found to have applications in locating aircraft on clear nights and also as a means of secret signalling (a hot body alternately exposed and covered being presumably used as the sending apparatus).

Secret Signalling with Ultra-Violet Rays.

Messrs. I. G. Priest and K. S. Gibson describes some attempts to use ultra-violet rays as a basis of secret signalling. The source selected was a right-angled arc (preferably with iron electrodes) consuming 25 amperes and screened by Corning glass of a variety suitable for restricting light to the ultra-violet between 340–350 mm. Experiments were made at a range of about 200 feet, a rotating sector being used to give the effect of greater distance. The receiver consisted of a short focus quartz lens forming an image on a fluorescent screen (uranyl sulphate was the most sensitive material tried). The screening of the observers' eyes by a close-fitting shade cutting off all extraneous radiation, and a thin piece of "purple-ultra" glass was found essential to sensitiveness. At the above distance, and with a sector-disc allowing 4 per cent. transmission (apparently equivalent to a distance of about 5,000 feet) the fluorescent images could be quite clearly seen. The method thus presents promising features as a system of secret signalling at comparatively short ranges. It was found impossible, however, to render the source of ultra-violet energy completely invisible. The source was always visible at close quarters, and from the receiving station a faint blue-grey haze, if carefully looked for, could be seen—apparently due to the fluorescence of the eye-lens. The degree of visibility, however, varied greatly with different observers, being a function of age. It is suggested that in order to render the source inconspicuous it might be camouflaged by the presence of adjacent visible lights, so that the act of signalling could not be detected without the use of the fluorescent receiver. It also appears possible that the method might be used with success under daylight conditions.

---

* *Physical Review*, August, 1919.

Optical and Photographic Methods of Detecting "Invisible" writing.

Another note of great interest, by Messrs. I. G. Priest and E. P. T. Tyndall, describes the use of optical and photographic methods of examination for invisible writing on suspected papers and documents, as used by the Office of Naval and Military Intelligence. These methods included (1) examination by intense illumination at grazing incidence, (2) examination by regular reflection, (3) examination by fluorescence, and (4) ultra-violet photography. A detailed report of this work is to appear in the military reports of the Bureau of Standards.

SHORT SIGHT IN SCHOOL CHILDREN.

In the *British Journal of Ophthalmology* for July, Dr. Ernest Thomson, ophthalmic surgeon to the County of Lanark Education authority, presents some interesting statistics on the prevalence of myopia among school children. The percentages of myopic children recorded are considerable, varying from 15 to 35 per cent. It has commonly been asserted that children in the slums of crowded cities more readily become myopic than those in country districts, owing to the fact that their eyes are mainly directed on objects at close quarters. Dr. Thomson's statistics, however, do not bear out this view. Schools in both types of districts were examined and the same order of percentage was observed in both cases. Children of miners, however, appear to be more subject to myopia than those of agricultural labourers or dwellers in cities. The possible causes of myopia are many, and among these Dr. Thomson includes bad hygiene and bad lighting, both in the school and in the home. Here, he suggests, is a wide scope for future investigations.

CANDLES AND SUPERSTITIONS.

The *Co-partnership Journal* for July contained some notes on the many superstitions associated with the use of light, especially with the use of candles. Thus, in the legends relating to St. Thomas, of Canterbury, it is stated that the Bishop of Poictiers returning from a visit to this city was met by a procession at the head of which two candles were lighted. These were blown out by the wind but miraculously re-lighted to the great joy of all present. The so-called "corpse candle" or "Will-o-the-wisp," a common phenomenon in marshy ground, has long been regarded as conveying a message of tragic import, and there is a Yorkshire custom of recovering the body of a drowned man by floating on the water a lighted candle.

A NEW HIGH VOLTAGE, LOW CANDLEPOWER ELECTRIC LAMP.

It is stated* that a new form of electric lamp, which meets the want of a high voltage unit of low consumption, has been designed by the firm of Pintsch in Berlin. As is well known, the making of metal filaments lamps of 10 watts consumption or less for voltages of 220 presents considerable difficulties. In this case it has been sought to produce the desired effect by a new departure, namely, the use of a luminous discharge in a mixture of neon and helium gas at 8—10 mm. pressure, within an ordinary clear bulb with standard socket. The bulb contains a large surface cathode and an anode at such a distance that at 190 volts pressure a faint discharge is set up yielding a small candlepower, and involving a consumption which need not exceed 1—5 watts. The lamp is intended for any 220 volt circuit, the remainder of the voltage being absorbed by a series resistance, concealed in the lamp socket. It is suggested that this lamp will be useful in cases where only a very small candlepower is desired.

---

* The *Technical Review*, Sept. 30, 1919.

NOTES ON THE SHIPPING, ENGINEERING, AND MACHINERY EXHIBITION.

Held at Olympia, September 25th—October 17th.

By An Engineering Correspondent.

The Shipping Engineering and Machinery Exhibition, which was opened by Lord Weir at Olympia, on Septemper 25th, contained much of interest to the engineering world. The Exhibition was well patronised, over 350 British exhibitors taking part. A number of official visits by engineering bodies took place, papers being read in some instances, and arrangements were also made for a series of cinema displays in the course of the exhibition. Among the latter we note a demonstration by the British Industrial "Safety First" Association, which took advantage of this favourable opportunity of drawing attention to the importance of safety measures in the industrial field.

Although many of the exhibits were of great engineering interest, however, it cannot be said that there was very much that was striking to record in connection with lighting; a fact which is surprising when one considers how many opportunities for the use of light there are in navigation. So far as the actual lighting of exhibits is concerned, there was little indication of concerted plan. In general, exhibitors followed their own fancy. In many cases unshaded gas-filled electric lamps were in painful evidence, in others more subdued lighting was used; but the effect was largely spoiled by the glare from neighbouring stalls. Both as regards lighting, and as an instance of coordinated systematic display, the Holland section of the exhibition was much in advance of the remainder. Occasionally one noticed instances of effective use of light. We may instance, for example, the lighting of the tanks used for the display of divers' apparatus by Siebe, Gorman and Co., Ltd., and one very neat model exhibit of a saloon and suite, lighted by miniature lamps, shown by the Royal Navigation Steam Packet Co., Ltd.

Lighting Plant.

There were on view a number of examples of compact petrol-driven electric lighting plants suitable for lighting bungalows, country houses, etc. Thus R. A. Lister and Co., Ltd., showed their standard automatic plant working on petrol or paraffin for domestic use, and also two plants, 6 kilowatts and 18 kilowatts respectively, devised especially during the war for emergency ship-lighting. In view of the dangers attending a failure of the normal method of lighting on board ship there would seem to be considerable scope for plant of this description. A. Lyon and Wrench, Ltd., exhibited the Lyon-Brotherhood self-starting plant, two types, one for 24 volt, the other for 50 volt being described. It is calculated that, assuming half-watt lamps are used, a twelve-room house can be lighted for 2s. a week. Other plants on show included that by Boulton and Paul, Ltd., the radiator-cooled 1 kilowatt set, being similar to those supplied to the military authorities during the war.

Acetylene Lighting Appliances.

Acetylene was naturally much in evidence on account of its use for welding work, as well as for lighting. Among those who exhibited may be mentioned Carbic, Ltd., the Dissolved Acetylene Co., Ltd., the Thorn and Hoddle Acetylene Co., Ltd., and the Acetylene Corporation of Great Britain. Apart from the purely cutting and welding appliances, the use of flare lamps and hand lamps on board ship was well illustrated, and there were some tasteful examples of ordinary lighting fittings. Amongst these might be mentioned the semi-indirect fittings shown by the Thorn and Hoddle Acetylene Co., Ltd., illustrating how this method of lighting can be used with acetylene.

as readily as with electric lighting. Acetylene lamps with dioptric lenses and equipped with a time-valve so as to flash the light at prescribed intervals were also shown, though not so fully as might have been anticipated in view of the developments of automatic flashing acetylene lights for buoys, etc., in Norway and elsewhere.

The Holland Section.

Besides being extremely interesting in itself as an orderly exhibition of the Dutch Shipping Industry, this section of the exhibition was of special interest by reason of the uniform method of lighting adopted, *i.e.*, by overhead semi-indirect fittings containing gas-filled lamps, some, we understand, up to 1,500 watts. The fact of the lamps being well overhead, as well as screened, prevented any impression of glare and left a clear view of the well-lighted exhibits below.

We understand that these lamps and fittings were manufactured by Philips Glowlamp Works, of Eindhoven, who also exhibited some special lamps for lighthouse work, which have features of considerable interest. Through the courtesy of the Sloan Electric Co., Ltd., their London Agents, we are able to give some details of these lamps. The lamps on exhibit included a 2,400 watt (30 amp., 80 volt) type, with a specially disposed filament for use with dioptric lenses, and some smaller types for use where less intense sources are desirable. The latter included a 2·5 amp. 220 volt lamp with parabolic reflector, giving a maximum of 13,500 candlepower, suitable for use on lightships, and a 200 candlepower type with dioptric lens giving a nominal candlepower of 1,200. Great interest attaches to the large gas-filled lamps which have been the subject of very complete study. The design of the filament, in particular, has to be studied from several standpoints. With a view to obtaining a concentrated beam, the filaments should be packed away within a small space, and should, if possible, give a substantially uniform incandescent area. Apart from this, the distribution of light must be such that the prisms most remote from the filament receive an adequate contribution of candlepower, and we believe that the form of filament now most favoured represents a combination of filaments in two planes crossing each other perpendicularly. With the 2·5 kilowatt lamp now produced, a nominal candlepower of 150,000 has been attained, but with the larger 4 kilowatt type (80 volts 50 amp.) in prospect, the candlepower will approach 450,000. Such lamps will be available shortly, and, when used for coast lights, will be fed by 8 h.p. petrol-driven generators. An interesting side-issue is the use of argon. With a relatively low voltage pure argon might be used with advantage for such special lamps, but for the contemplated pressure of 80 volts a mixture of argon and nitrogen is favoured. It is anticipated that these lamps will largely replace arc lamps on many coast stations.

Another interesting feature in this exhibit was a map showing the optical range of lights at present installed on the Netherlands North Sea coast.

Searchlights.

Searchlights were exhibited by several firms, for example, by Messrs. Siemens Bros. & Co., Ltd., and by the London Electric Firm. The latter including among their exhibits "all brass" types suitable for use on board ship. The Sperry Gyroscope Co., Ltd., exhibited the Sperry High Intensity Searchlight, and the interesting statement is made that this form of lamp has been utilised by leading cinematograph film producers for motion picture production. Messrs. C. A. Parsons & Co., Ltd., showed specimens of parabolic searchlight reflectors as supplied in large numbers during the war. Of special interest are the split reflectors. The reflector is divided into halves, which are hinged to one another, enabling either a single or divided beam to be obtained. The adjustable nature of this contrivance has proved of value on many occasions, for example, on the Suez Canal for lighting up buoys at the side of the canal. For canal work about 12° dispersion is commonly used, but on the approach of another ship one may produce a dark centre so as to prevent the pilot on the approaching vessel being dazzled by the light of the projector. Small searchlights for yachts, miners' hand lamps, etc., were shown by Worsnop & Co., Ltd.

Miscellaneous Lighting Devices.

The Fairless Engineering Supplies Co., Ltd., exhibited the special "anti-break" lamp economiser, which has been previously described in this journal. It will be recalled that the device consists essentially in the support of the lamp on a series of phosphor-bronze strips, arranged obliquely, and has been found very useful in protecting lamps against shock in engine rooms, on ships above the propeller, etc., and generally in circumstances when there is much vibration. A feature of interest to which reference has not previously been made is the use of a double series of gauze discs for supporting lamps in large lanterns (*e.g.*, lamps of the gas-filled type) whereby any inconvenient sideways play is eliminated. This firm also showed various forms of gas-filled lamp lanterns and fittings, supplied with the device.

A variety of simple metal reflectors was shown by the Reflecto-Metal Co., Ltd. These reflectors are very light in construction and are available in various shapes. In view of the shortage of shades and reflectors at the present time they should be useful. A number of firms showed oil and electric bulkhead fittings, lanterns and other special lighting devices for use on board ship. Among other exhibits we note that the well-known Petrolite lamp was on view, and there were also various specimens of ingenious and pleasing forms of coloured signs. The "magicoal" fire of Berry's Electric, Ltd., while strictly a heating exhibit, deserves mention for the ingenious device whereby the rising currents of air cause motion of light mica vanes, producing a flicker of light which closely simulates the effect of dancing flames.

ADJUSTABLE OVERHEAD LIGHTING FIXTURES.

It is commonly urged as an advantage of overhead general lighting that, as the illumination is uniformly distributed, the positions of desks, machines, etc., can be altered without any alteration in the lighting arrangements being necessary. In many cases this is broadly true, especially where there is considerable diffused light from walls and ceilings. But there are certain cases, especially when machinery involving cutting edges is in use, where the direction from which light comes is of great importance. A few feet displacement of the adjacent fittings one way or another may render light-shadows either convenient for the work or very troublesome; on the other hand, when one is dealing with small edges, recesses, etc., it may not be desirable to have complete diffusion of light and very very soft shadows, even if the nature of the workroom allows this to be done.

It is therefore an advantage, after the positions of outlets at uniform intervals have been generally determined, to be able to go over the fittings and make a final displacement of a few of them with a view to the positions of particular machines. An arrangement facilitating such displacements is described in the *Electrical World*. It consists of a lighting fixture supported by a short length of iron tube, terminating in a metal loop. This can be placed over a hook fixed in the ceiling, and the weight of the fixture is taken by this hook, not by the flexible wire. A short length of flexible connecting wire passes down the tube to the lamp-holder, and carries at its other end a plug connector which can be inserted into the outlets spaced uniformly on the ceiling. If it is desired to alter the position of such a fitting slightly, it is easy to displace the hook slightly while retaining the same outlet box, and only a short length of flexible connector is needed. We understand that this device has been used by some illuminating engineers in this country with advantage, and it deserves to be more widely known.

LIGHTING VULGARITIES.

In view of the tendency to the misuse of powerful unscreened lamps in shop-windows, which has been the subject of recent reference in this Journal, it is interesting to observe in *Electrical Industries and Investments* an article by Mr. H. E. Goody, which was written a few days before the outbreak of war, but has special application to the conditions prevailing at the present time.

"Almost every day," it is remarked, "sees the indictment by the Press of some modern evil or abuse. . . . Elementary Education, the London Traffic Dangers, the Cab Whistle, all receive attention in turn, but insufficient heed is paid to the abuse of light, especially as instanced by the singular habit of shopkeepers of festooning their façades with powerful, unscreened lamps. Outside shop-lighting as practised in suburban streets is a hideous eyesore.

"'The Public Rights' aspect of the case is this. We elect local authorities to carry out various duties, one of the most important of which is the lighting of our streets. If it is not done adequately, there is always (or rather every three years) the remedy of the ballot box, and we do not want tradesmen to act as amateur street lighters, any more than we want barristers to vary the monotony of legal routine with road cleaning or dust collecting."

"Then there is the personal aspect. Why should the pedestrian be subjected to the discomfort of glaring high pressure gas lamps or electric arc lamps when taking his evening walk ?"

"It is difficult to guess the shopkeepers' motives for this indiscriminate and uncomfortable illumination, for it is obvious that a shop window can be lighted more effectively, artistically, and economically from the inside than from the outside. . . . Love of ostentation would appear to have been the predominant motive in outside shop lighting: because it is really nothing but sheer vulgar display. The number of lamps a man sticks along his shop front bears no relation to (or only an inverse one) to his business acumen or enterprise. A man who hangs ten 1,000 candlepower lamps on a ten yards frontage might just as well adopt the less expensive and more informative method of pasting the leaves of his bank pass book on his shop windows. He could do this without spoiling the look of the windows or the eyesight and comfort of prospective customers. It will, of course, be claimed by defenders of outside shop lighting that it attracts custom. As a matter of fact it does precisely the reverse. This can be proved by anyone who stands for some little time in a shopping street, which depends on casual rather than regular custom. The observer will notice that people instinctively and, perhaps, subconsciously avoid the more blatantly lighted shops and go to those which can be approached without an uncomfortable contraction of the pupils of the eyes. That such lighting is not essential to successful trading is sufficiently proved by the fact that several of the large West End shops have recently removed all their outside lamps and rely entirely on interior illumination. Needless to say, the appearance of the windows is infinitely better, the cost of lighting very much less, and it is natural to suppose that the increased attractiveness of the windows will have a salutary effect upon the volume of business."

In the suburbs, however, the fever is at its height. One remedy would be to pass a law prohibiting the use of outside lamps by private persons. This would not be a very revolutionary matter, since there are already L.C.C. By-Laws regulating the use of illuminated and hanging signs.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments. and we welcome the receipt of all *bona-fide* information relating thereto.]

THE MEANING OF MAZDA.

A Story for Children.

The children of to-day are the buyers of to-morrow. Accordingly, the B.T.-H. Co., as an item in their new season's publicity campaign, have issued a painting book, addressed primarily to children, and illustrating in a simple way the mythological origin of the word " Mazda," which in ancient Persian means the " Supreme Light." A number of line drawings are employed to illustrate the progress and issue of the age-long combat between Mazda—the spirit of light—and the swart and malevolent Angro, who personifies the darkness which has been finally routed by the Mazda half-watt type lamp.

Limited quantities of this booklet, *The Meaning of Mazda* (L.129) will be supplied, overprinted with contractors' names and addresses, on application to the British Thomson-Houston Co., Ltd., 77, Upper Thames Street, London, E.C.4.

OSRAM AUTOMOBILE LAMPS.

A leaflet issued by the General Electric Co., Ltd., gives particulars of Osram lamps suitable for use with British, French and American cars, including headlight, sidelight, tail and dash-board lamps, etc. A special feature is the Osram Atmos (" half-watt ") lamp for headlight use, the small superficial area and high intrinsic brilliancy of the filament being very favourable to projection work of this kind.

LIGHTING FOR PROTECTION.

A Strike Episode.

An interesting incident during the recent railway strike was the use of B.T.-H. Projectors at Lots Road Power Station. These projectors are mounted on tripod stands, and can be swivelled horizontally and vertically. Each projector is equipped with a 1,000-watt Mazda half-watt type lamp. Two or three watchmen, each having under his control a B.T.-H. flood light projector, could maintain close observation over the whole danger zone, *i.e.*, the area from which interruption was likely to proceed. It is stated that even slight movements of twigs or papers could be clearly seen at a distance of 300 or 400 feet. As is well known, the floodlight projectors have been largely used in the United States during the war for the protective lighting of important buildings.

SUNLITE LANTERNS FOR GAS-FILLED LAMPS.

A recent list issued by the **Sun Electric Co., Ltd.,** gives particulars of three new models of the Sunlite lanterns for gas-filled lamps ; two are suitable for lamps up to 3,000 candlepower, the other for lamps up to 1,000 candlepower. While specially adapted to exterior lighting, the lanterns are also suitable for many forms of interior lighting. A feature is the combination of adequate ventilation with weather-proof properties, and we are glad to see that the fittings are all provided with opalescent globes, eliminating glare without undue loss of light.

GAS-ELECTRIC CINEMA LIGHTING GENERATING SETS.

An interesting problem is the question of using gas-driven electric sets for cinema projector work. As is well known the consumption of the arc-projector is often very considerable, so that any economy in generation is well worth while. Again, in some cases the supply voltage is inconveniently high, leading to an inefficient loss of power in series resistance if current is taken direct from the supply mains. In other cases alternating current is available, and this is not so suitable for projection work as direct current, as there is not the same well-defined arc-crater. Therefore, it is usual to install a motor-converter, so as to get the ideal voltage and nature of supply for the projector, and avoid losses in series resistance.

The question arises, however, whether in such instances it is not better to rely entirely on private generation by installing a suitable gas-driven electric set. If this is done, not only the projector but the lighting of the hall, and the load involved in any special electrically-driven appliance used can be carried by the gas-driven set. A case in point, the Central Hall Cinema at Doncaster, was recently referred to in *One Thousand and One Uses for Gas.* Originally current was taken from the town mains at 200 volts and reduced by motor-generator to 70 volts. The cost per unit for lighting was 4½d. a unit, for the motor-converter 3d. a unit. For the last three weeks in January, 1914, the average lighting cost was £1 0s. 4d. and for the converter £1 13s. 4d. per week, the total cost being thus £2 13s. 8d. weekly. (It is interesting to remark that in this case the cost of energy for the projection of pictures apparently exceeded the total cost of the lighting of the building.)

The installation of a gas engine and dynamo in March, 1914, led to a considerable saving. The gas consumption was approximately 4,900 cubic feet weekly, which at the prevailing rate of 1s. 11d. per 1,000 cubic feet for gas, meant an outlay of 9s. 6d. only, the difference being thus £2 4s. 2d. weekly. The *Gas World*, by further analysis of the figures, draws the conclusion that the cost of current generation was 0·875d. per unit. as compared with the service rates of 3d. and 4½d. respectively. Making full allowance for oil, repairs, depreciation, etc., it is estimated that the plant could be run at 1¾d. per unit. In general, for ordinary halls, a 13 k.w. set with an engine of 20—25 B.H.P. will do what is necessary while for large halls, with other special electric appliances up to 30 k.w. may be required. With a mean load of 50 units per hours per diem, it is considered that a saving of 1½d. per unit and a total annual saving of about £450 might be made.

These figures would doubtless require some modification in view of the increase in the cost of both gas and electricity during the war, but, on the above showing, the prospects of gas-driven plant for cinema work would seem promising. In any case it furnishes an interesting example of the co-operation of gas and electricity in the lighting field.

"CAUSE AND EFFECT."

The pamphlet issued by the Benjamin Electric, Ltd., under the above title is arranged in a somewhat novel and striking manner. The booklet deals with industrial lighting. A brief preface is included referring to the importance of good illumination in preventing accidents and improving output and quality of work. Throughout the list the left-hand page is devoted to particulars (including general view, polar curve, and structural details) of various lighting units ("The Cause"), while on the corresponding right-hand pages photographs of typical installations using these lighting units, and illustrating "The Effect," are presented.

At the end there is a readable summary of the advantages of good lighting and of the main principles to be observed in factory lighting. The direct relationship between good lighting and efficient production is insisted upon. Reference is made to the interest now being taken in the subject by Government Departments in this and other countries, and to the great advances that have been made in a knowledge of illumination through the work by the Illuminating Engineering Society. We are glad to see the case for good industrial lighting so well and clearly put, and to note how leading manufacturers of light appliances are thus assisting in educating the public to appreciate these facts.

A NEW STREET-LIGHTING LANTERN.

The use of gas-filled lamps for street lighting has made the design of special lanterns an important matter. It is now generally recognised that the mere insertion of such a lamp into an existing fitting, intended for arc lamps or ordinary vacuum incandescent lamps, does not usually give good results. Attention has to be paid to the distribution of light, the correct focussing of the filament, and above all to the ventilation.

Our attention has been drawn to the "City" lantern recently introduced by the General Electric Co., Ltd., for use with "Osram Atmos" lamps, up to 1,500 watts. A general view of the lantern is shown in Fig. 1, while Fig. 2 shows the polar curve of light distribution, as determined by the N.P.L. The contour of the reflector is designed with a view to a wide angle of light distribution. A feature of interest is the special focussing device which enables the filament to be maintained in the correct position to secure this distribution; the lamp, after being screwed in position being merely pushed gently into the right position and held by a spring ratchet device. Special attention has also been given to the problem of ventilation, so as to avoid "trapping" the hot air in the upper part of the lantern, and yet to provide a suitably weather-proof construction. Two patterns of the lantern, one with a spun steel reflector, weighing 21½ lbs. for general use, the other of more massive construction for use in exposed positions, weighing 35 lbs.

We understand that the Illuminating Engineering Department of the General Electric Co., Ltd., will be glad to assist engineers engaged upon street lighting problems and to draw up suitable schemes to meet requirements.

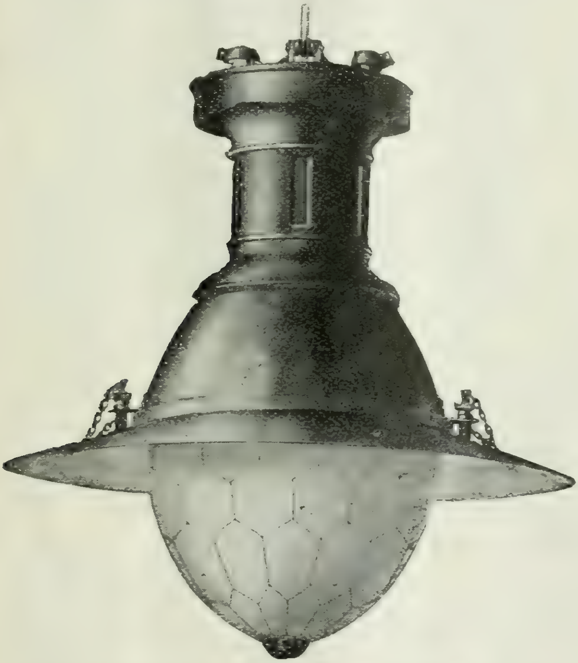


FIG. 1.—General view of "City" Street-Lighting Lantern.

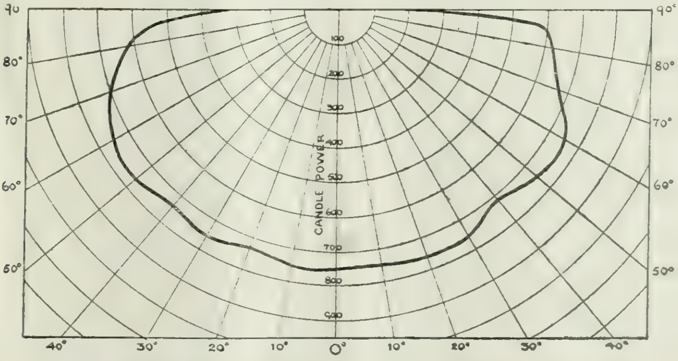
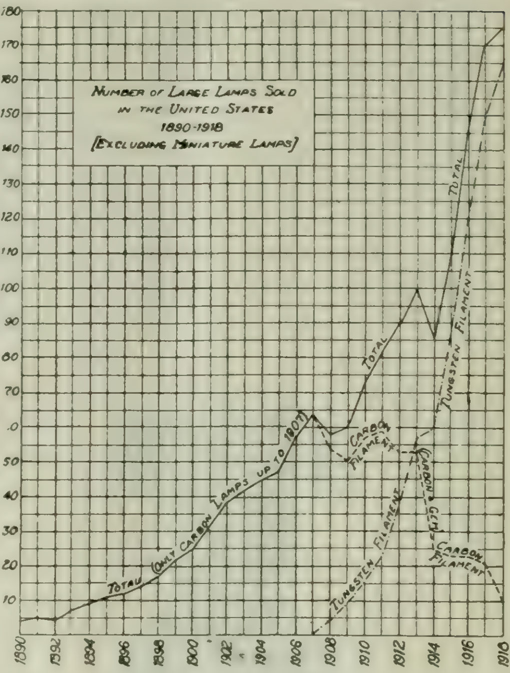


FIG. 2.—Distribution of light from "City" Street-Lighting Lantern.

PROGRESS IN ELECTRIC INCANDESCENT LAMP SUPPLY IN THE UNITED STATES.

Some time ago we referred to some interesting statistics published in the *General Electric Review* (U.S.A.) relating to developments in electric lighting. The accompanying chart, reproduced from this article, is of special interest as showing the sales of incandescent lamps during the period 1890 to 1918. A feature of interest is the rapid growth in the proportion of lamps of the gas-filled ("half watt") type.



THE SHORTAGE OF LAMPS DURING THE WAR.

In an account of war activities of various firms given in the recent paper by Messrs. A. B. Gridley and A. H. Human before the Institution of Electrical Engineers, reference is made to the shortage of lamps during the war, owing to Government demands. It is stated, for example, that of the lamp production of the British Thomson-Houston Co., Ltd., 45 per cent were direct Government orders, and 59 per cent. A. and B. class orders, so that very few lamps (apparently only about five per cent.), were available for export or domestic service.

FIRE FIGHTING BY FLOODLIGHT.

The B.T.H. Floodlight Projector and its various applications have already been described in these columns, and we have recently received an account of a demonstration of its use by the Dundee Fire Brigade Department as an aid to fire fighting at night. The projector used in this demonstration was of the ordinary portable type, mounted on a tripod, and was fitted with a 1000 Watt Mazda Gas-filled ("Half-Watt") Lamp. By the aid of its powerful beam firemen working at a height of 400 feet could be identified, and the adjacent area being treated was brightly illuminated.

In some cases the light of the fire naturally provides sufficient illumination for the work of the fireman, but in others the fire brigade is compelled to work in comparative darkness, to the detriment of their salvage efforts.

The projector is portable and readily adjustable, in the sense that its beam can, at a moment's notice, be projected in any desired direction. It can be operated from a small generator coupled to the pumping engine, or, better still, facilities for connecting to the electric mains should be provided at every fire hydrant position. The projector could also be easily connected up to any electrically lighted house in the neighbourhood, or to a street lighting standard.

INDEX, October, 1919.

PAGE
Candles and Superstitions .. 296
Editorial. By L. Gaster .. 279
Gas Burners, Free Maintenance of .. 285
Heat and Ultra-Violet Radiation in the War, The Use of .. 295
Illuminating Engineering in Germany .. 294
Lighting Restrictions in Paris .. 285
Lighting of Interiors of Cinema Halls, The .. 290
Lighting of Subways and Underground Passages, The .. 292
Lighting Vulgarities .. 300
New High Voltage Low Candlepower Electric Lamp, A .. 296
Overhead Lighting Fixtures, Adjustable .. 299
Personal Notes .. 305
Public and Private Lighting, Recent Developments in. By W. C. Clinton 287
Reviews of Books and Publications Received:—
The Review of the Foreign Press—The Technical Review—Elements of Vector Algebra, by L. Silberstein—Business Organisation and Management—Journal of the Franklin Institute .. 306
Scientific War Time Public Lighting in Paris .. 293
Shipping, Engineering, and Machinery Exhibition, Notes on the .. 297
Short Sight in School Children .. 296
Specification for Tungsten Electric Lamps, A Japanese .. 283
Street Lighting and Traffic Accidents. By Ward Harrison .. 286
Switching Requirements in Large Buildings .. 285
Technical and Scientific Professional Associations, The Federation of .. 306
Topical and Industrial Section:—
The Meaning of Mazda—Osram Automobile Lamps—Lighting for Protection—Sunlite Lanterns for Gas-Filled Lamps—Gas-Electric Cinema Lighting—"Cause and Effect"—New Street Lighting Lantern—Progress in the United States—Shortage of Lamps during the War—Fire Fighting by Floodlight .. 301

PERSONAL NOTES.

Editorship of the "Electrician."—On Friday, October 31st, Mr. W. R. Cooper, M.A., B.Sc., M.I.E.E., A.M.I.C.E., was presented by his colleagues of Benn Brothers with a silver rose bowl and Weston portable milli-ammeter, upon his retiring from the editorial chair of the *Electrician* after a period of 13 years. Mr. Cooper has decided to devote the whole of his time to his consulting practice, the growth of which renders it impossible for him to continue his editorial duties at the same time. Mr. Cooper was appointed Editor of the *Electrician* in 1906, and under his editorship the journal has made considerable progress. His place will be taken by Mr. F. H. Masters, O.B.E., A.M.I.E.E., who was chief assistant editor at the outbreak of war in 1914. Mr. Masters received his technical training at King's College, London, and Finsbury Technical College, under the late Prof. S. P. Thompson. He was afterwards engaged in sub-station work on the Central London Railway, and in the Electrical Engineers' Department of H.M. Dockyard, Chatham. He joined the *Electrician* staff in 1906, and was subsequently appointed chief assistant to the Editor. During the war he was engaged on coast defence electric lighting work and on searchlights used against enemy aircraft. He contributed considerably to the development of these defences, and did very useful work in the training of the men engaged upon them. Mr. Masters was awarded the O.B.E. and was twice mentioned in despatches.

Sir Henry Alexander Miers, D.Sc., F.R.S., Vice-Chancellor of the University of Manchester, has been appointed by an Order of Council, dated October 16th, 1919, to be a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

The Review of the Foreign Press. (Issued by "Review of the Foreign Press, Ltd.," Watergate House, Adelphi, London, W.C.2.)

READERS will doubtless be aware that during the war a review of the foreign, political, economic and technical press was issued by the War Office. The continuation of this work is now being undertaken by a private enterprise, through the medium of the Review of the Foreign Press, Ltd. Two publications the *Economic Review* and the *Political Review*—are being issued weekly, and the journals will be under the supervision of an influential Editorial Advisory Council. Captain W. E. Barber, the Editor, is receiving the assistance of many of the staff who assisted him under the War Office. In these times there is a great need for the dissemination of information regarding progress in foreign countries, and we wish the new venture every success.

The Technical Review. (Published at 20, Tavistock Street, Covent Garden, London, W.C.2.)

WITH reference to the above announcement, readers will also recall that a Technical Supplement was issued by the War Office, containing a summary of articles in the foreign technical press. This work is also being continued by the issue of *The Technical Review*, which appears weekly, and aims at abstracting articles appearing in a great variety of foreign periodicals—in fact, at conducting "intelligence" work on behalf of the engineering industry. The publication will doubtless be of interest to many of our readers.

Elements of Vector Algebra. By L. Silberstein, Ph.D. (Longmans, Green and Co., London. 1919. *5s. net. pp.* 42.)

THIS little book, by Prof. Silberstein, of the University of Rome, has been written as an aid to an understanding of the methods used in his previous treatise on "Simplified Methods of Tracing Rays, etc." It covers the elements of vector algebra required in geometrical optics, and is interesting as a novel method of treating problems of this nature. The book is well printed and contains suitable illustrative diagrams.

Business Organisation and Management.

A NEW monthly journal has been recently issued by Sir Isaac Pitman and Sons, Ltd., with the above title, at the price of 1s. 6d. net. The first issue deals with a variety of subjects of topical interest by well-known authorities in their respective fields. Among the articles is included a contribution by Mr. Leon Gaster on "Office Lighting," in which reference is made to some of the chief principles illustrated at the discussion on this subject before the Illuminating Engineering Society early in the present year. The subsequent issue of the journal contains a second article by Mr. Gaster on "Industrial Lighting."

Journal of the Franklin Institute.

THE *Journal of the Franklin Institute* for October contains several articles of considerable interest. The serial article by Prof. W. J. Humphries on "The Optics of the Air," is continued, many natural phenomena, such as rainbows, the staircase effect on clouds, the apparent convergence of sunbeams, etc., being explained. Mr. L. A. Jones deals with "Low Visibility Protective Colouration," some interesting examples of the camouflage effect in ships being illustrated.

THE FEDERATION OF TECHNICAL AND SCIENTIFIC PROFESSIONAL ASSOCIATIONS.

At a meeting of the above Association, held on September 6th, fourteen associations, representing the interests of about 50,000 professional officers and servants, were present. Mr. A. C. J. Charlier (President), presided. The Draft Constitution was adopted, and it was agreed that qualified bodies agreeing to adhere thereto previous to the date of the next meeting on October 18th should be considered original members. It was also decided to form Group Committees for such professional interests represented to advise the Federal Council. The adherence of the British Association of Chemists was announced, and it was intimated that the Society of Technical Engineers would probably also become members.

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

The
ILLUMINATING
ENGINEER
Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

Recent Developments in Illuminating Engineering.

The first meeting of the Illuminating Engineering Society during the present session, held on November 25th, was devoted to a very varied programme. This being the opening meeting of the session following the termination of war, it was appropriate that attention should be given mainly to reports of progress and exhibits of novelties in connection with illuminating engineering, a practice which it is proposed to make a general rule for opening meetings in future years.

The brief address delivered by the President on "Lambert and Photometry" (see pp. 313-315) contained a survey of some of Lambert's early photometric researches, showing how well he understood the main principles involved in the measurement of light, including the famous "Cosine Law." It is strange, as the President remarked, that Lambert does not appear to have actually constructed a photometer (although he recommended that one should be "excogitated"), and the credit for having devised the first instrument for measuring light apparently rests with Bouguer. In view of this account of Lambert's early and historic work, the exhibit of a new form of illumination-photometer by Mr. Haydn T. Harrison later in the evening was timely. The instrument (see p. 328) seems to present some novel features, and it was interesting to have before one, on the same evening, a record of some of the very earliest work in this field, and an exhibit illustrating the very latest researches.

Following Mr. Trotter's address there came the usual "Notes on Events during the Vacation" (see pp. 316-318), in which an account was given of the work being done by three of the newly-formed special committees, dealing respectively with Progress in Lamps and Lighting Appliances, Eyestrain in Cinemas, and Railway Lighting. It was naturally only possible to give a very general survey of this work at the moment, but it is clear that all three committees have useful work before them; in the immediate future the work of the Society should be considerably extended through the activities of such Joint Committees. A new feature was the Report presented by the Committee on Progress in Lamps and Lighting Appliances (pp. 319-322). The present report is confined to electric lamps but it is hoped in future to have similar annual reports dealing with progress in gas lighting and other methods of illumination. Meantime it is well to have available a statement of the present position in the electric lamp and fittings industry, so that the difficulties experienced during the war, and still prevailing to a great extent, may be understood. The hope is held out that in the near future many of these difficulties, notably in connection with the shortage of certain types of lamps and fittings, will be largely overcome. The tabular data illustrating the demand for various types of lamps during the war period mark an important precedent as affording the first authoritative data published on the subject in this country. It must, however, be understood that this is merely a commencement, and that further data are needed for a complete interpretation of the figures presented. One would like to know, if possible, something more of the distribution of the demand for lamps, i.e., the proportion required for domestic lighting, industrial illumination, and in streets, etc. It seems probable that the replacement of arc lamps by gas-filled ("half-watt") lamps for street-lighting would have a material influence on some of the figures presented.

Two other exhibits at this opening meeting, the various "pointolite" lamps shown by Mr. Freedman, of the Ediswan Laboratory, and the "Sheringham Daylight Lamp" exhibited by Mr. L. C. Martin, of the Imperial College of Science and Technology, deserve attention. The pointolite lamps are expected to have useful applications for various special purposes, one striking advance being in the direction of high candlepowers (up to 4,000). The account presented by Mr. Freedman reveals creditable perseverance in developing this special line of work, in spite of the distractions of the war.

The Sheringham Daylight Lamp has received a considerable amount of notice in the Press. The idea of imitating daylight by artificial means is, of course, familiar and has been dealt with on several occasions before the Society, for example, in the discussion initiated by Mr. T. E. Ritchie in 1911. The method described of using reflected light from a special coloured reflector has not hitherto been studied in detail. The research involved is interesting for the fact of its being the combined work of a physicist, Mr. Martin, an artist, Mr. Sheringham, and an expert in camouflage, Major Klein. As, however, the whole subject of colour by natural and artificial light is to be dealt with fully by Mr. Martin in a paper before the Society in the near future, we postpone further comment for the moment.

A New Basis for Rating Gas.

Among the developments of the present year in the field of gas lighting few are more important to the consumer than the proposal outlined in a Report presented to the Board of Trade by the Fuel Research Board, and discussed at the Conference on Gas Standards held at the Institution of Civil Engineers on October 28th.

The matter is a highly technical one, but some of the main points in these proposals may be summarised as follows: It is proposed that consumers should be charged for the actual thermal units supplied in the gas passing through the meter, calculated by multiplying the number of cubic feet of gas supplied by the calorific value per cubic foot. Thus 1,000 cubic feet of gas of 500 B.T.H. standard would be charged as 500,000 units. With gas of the above quality selling at 50d. per 1,000 cub. ft., would cost 10d. (It is suggested that 100,000 such units might be called a "Therm.") The calorific value is to be measured and specified, and it is proposed to limit the standards to four, namely, 400, 433, 466, and 500.

Seeing that the consumer is primarily interested in the heating value of the gas he uses, it appears that the above would form a more equitable basis of charging, due account being taken of the quality of gas, as well as the amount consumed. Gas undertakings are also to confine the amount of inert constituents within prescribed limits, and supply a minimum pressure. Thus at the Conference referred to, it was suggested that there should be not more than 20 per cent. of inert constituents for two years, not more than 18 per cent. for two years thereafter and ultimately not more than 15 per cent.; also that within five years gas should be supplied at a pressure of not less than 20/10ths inches of water in any main or service pipe of 2-in. diameter and upwards.

A very important point from the consumer's standpoint, is that gas undertakings, according to the resolutions carried at the conference, shall agree to adjust and, if need be, replace gratis the burners in consumers' appliances, so that the gas delivered can be burned with safety and efficiency. This would also apply should the undertaking at any time decide to change the quality of gas, of which due notice to consumers must be given.

We appreciate this judicious recognition of the consumer's position and we have no doubt that in this matter leading gas concerns will follow their usual broad policy of caring for the consumer's requirements, besides merely supplying gas. It occurs to us, however, that in some cases dispute might arise as to whether the adjustment or replacement of appliances had been adequately carried out, and it might be desirable for some authoritative and impartial body to be constituted, who would be prepared to arbitrate in such a case.

The change, as we have said, is a far-reaching and complex one, and the details will require very careful consideration. We think, however, that there is general recognition, especially in view of the exceptional experience gained in regard to the effect of quality of gas during the war, that some more scientific method of rating is necessary, and the proposals now being considered are framed on bold constructive lines.

The 1919 Convention of the American Illuminating Engineering Society.

The Convention of the American Illuminating Engineering Society, held in Chicago during October 20th—23rd, appears to have been very successful, and was the occasion of a number of interesting papers. Dr. G. A. Hoadley, in his Presidential Address, referred to the war-activities of the Society and his part in reconstruction problems, dwelling especially on the importance of efficient lighting as an aid to rapid production. Mr. S. E. Doane, President-Elect, in support of this view, mentioned that 65 per cent. of the electric incandescent lamp output is used in places where the productive value of good lighting has immediate benefit.

One of the chief items on the programme was the symposium on industrial lighting, in which Mr. L. B. Marks and others prominently associated with the framing of codes on industrial lighting, summarised progress in their respective localities. We notice that another State, California, has now adopted a code, so that there are now six States which possess definite legislation on industrial lighting. These reports afford confirmatory evidence of the ease with which the regulations have been applied, and the general willingness to adopt improved lighting arrangements where necessary. Manufacturers, contractors and inspectors all co-operate in this work, and frequently lectures and demonstrations are arranged for their benefit. Naturally questions as to the interpretation of State codes have been raised, and in some instances these were settled by reference to the more elaborate code prepared by the Society. These developments should influence authorities in this country in giving effect to the recommendations already made by the Departmental Committee on Lighting in Factories and Workshops.

A variety of other papers was presented. We cannot deal with these in detail but we should like to draw attention to the discussion on "glare-tests," a point that certainly deserves consideration in this country. Although the general principle that glare should be avoided is admitted by experts, there is still difficulty in analysing on a scientific basis the bad effects of glare, and expressing these in numerical terms. Tests may proceed on the basis of eye-fatigue after prolonged exposure, by determination of the amount of interference with vision, or by momentary or "snap-judgment" methods. A reliable method of determining glare is much to be desired.

Of the other papers, some dealt with special applications of light in the war, for example, military searchlights, others with commercial and industrial lighting problems, and several forms of photometric instruments were described. Mr. F. W. Willcox gave an address on lighting conditions in England, in the course of which he referred to the valuable influence exerted by the Illuminating Engineering Society in this country. We are glad to note this evidence that the American Society, like our own, is resuming all its normal activities, and in the future there should be many opportunities for co-operation between the two bodies.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

RECENT DEVELOPMENTS IN ILLUMINATING ENGINEERING.

THE opening meeting of the session was held at the House of the Royal Society of Arts, London, at 5.30 p.m. on Tuesday, November 25th, THE PRESIDENT (Mr. A. P. Trotter) in the chair.

The Minutes of the last meeting having been taken as read the names of the following applicants for membership were announced :—

The HON. SECRETARY also read out again the names of the applicants for membership announced at the last meeting on June 24th* and these gentlemen were declared members of the Society.

THE PRESIDENT alluded to the death of Mr. S. D. CHALMERS, of the Optics Dept., at the Northampton Institute,

Ordinary Members :—

Barber, N. E.	Electrical Engineer, Messrs. W. Butcher and Sons, Ltd., 28, Denmark Street, London, W.C.2.
Evans, Lt.-Col. S. C. H.	Engineer, Inspector of Searchlights, Plant, etc., R.E., 111, Ritherdon Road, London, S.W.17.
Hiatt, Dr. C. E.	Electrical Engineer, Messrs. Edison and Swan Electric Co., Ltd., Ponder's End, Middlesex.
Hiley, G. J. O.	Lighting Superintendent, City of Birmingham Gas Dept., Council House, Birmingham.
Pizzuto, A.	Assistant Engineer, Government Supply Works, 130, Str. Forni, Valletta, Malta.
Rawlings, W. J.	Assistant Electrical Engineer, Messrs. Rawlings Bros., Ltd., 95, Gloucester Road, South Kensington.
Richards, S. H.	Electrical Engineer, 17, Muncaster Road, Clapham Common, London, S.W.
Swan, F. A.	Electrician, Manager and Treasurer of the Auxiliary Fire Alarm Co., 144, Oliver Street, Boston, Mass., U.S.A.
Willcox, E. J.	Electrical Engineer, 90, Kenilworth Road, Birchfields, Birmingham.

Corresponding Members :—

Matsui, K.	c/o T. Inumaru, 7, Koyama-Cho Tokyo, Japan.
Manolovici, J.	Engineer, Bucharest, Roumania.

Student Members (Associates) :—

Gaster, A. E.	University College, Gower Street, London.

---

* ILLUMINATING ENGINEER, August, 1919, p. 205.

who had been associated with the Society from its early stages, and had taken part in many of its discussions.

The President then delivered a short address on "**Lambert and Photometry**" (see pp. 313–315), summarising some of Lambert's early work. His *Photometria*, published in 1760, showed that he clearly understood the underlying principles of photometry, although he does not appear to have ever designed an actual photometer.

The HON. SECRETARY (Mr. L. GASTER) then presented the customary "**Notes on Events during the Vacation.**" It was mentioned that three of the projected new committees, dealing respectively with Progress in Lamps and Lighting Appliances, Railway Lighting, and Eyestrain in Cinema Theatres, had now commenced work. The National Illumination Committee had resumed its activities and the Society had been added to the list of those forming the Conjoint Board of Scientific Societies. Great interest continued to be shown in industrial lighting. It was hoped that in the near future a definite requirement of adequate lighting would be introduced into the Factory Acts.

Lieut.-Col. F. A. CORTEZ LEIGH, Chairman of the Committee on Railway Lighting, briefly explained the work of this committee. It was proposed to carry out tests on some of the chief railway systems of the country, with a view to ultimate agreement on some common principles in railway lighting.

Mr. J. W. ELLIOTT presented the Report of the Committee on Progress in Lamps and Lighting Appliances on **the Position of the Metal Filament Lamp and Fittings Industry at the Present Time.** The difficulties experienced during the war, and still prevailing to some extent, were explained. There was still a shortage of some articles such as British-made lamp-bulbs and some forms of reflectors, but in the near future there should be a considerable improvement in the position. Some curves were presented showing the demand for various types of lamps of different candlepower during the war period. Mr. Elliott also showed a new form of gas-filled lamp having a bulb made of white diffusing glass; the light was distributed uniformly over the bulb and the actual filament could not be seen.

Mr. L. C. MARTIN, of the Technical Optics Dept. of the Imperial College of Science, exhibited the **Sheringham "Daylight" Lamp,** originally devised by Mr. Sheringham, the well-known artist. The lower portion of the lamp was screened so that no direct rays reached the coloured material to be studied, and rays reflected upwards were received on a large reflector having on its inner surface a chessboard pattern in various colours. These colours were so selected that the reflected light closely resembled daylight and was well-adapted to operations involving accurate representation of colours.

Mr. P. FREEDMAN of the Ediswan Laboratory then exhibited "**Some New Forms of Pointolite Lamps.**" The original 100 candlepower lamp of this type was shown publicly for the first time before the Society in 1915. Since then there had been important developments, notably in the design of the ionisers, 500 and 1,000 candlepower types were now available, and a 4,000 candlepower type, which should be very useful for projection and cinema work, had just been completed. Other exhibits included low voltage lamps, special lamps adapted to pyrometric work, and a new device which was expected to diminish considerably the blackening of the bulb and increase the life.

Mr. HAYDN T. HARRISON showed a **New Form of Illumination Photometer.** Readings could be taken on an illuminated scale, reflected in a small mirror within the instrument. An aperture in this mirror, through which the detached test-plate could be seen, served as a pointer. The "pointer" was brought into photometric balance with the same portion of the illuminated scale, and the line of vision between the photometric surfaces was very fine, enabling an accurate balance to be obtained.

A vote of thanks to lecturers and exhibitors closed the proceedings after which the PRESIDENT announced that the **next meeting** would take place at **8 p.m.** on **December 16th** when CAPTAIN W. A. HOWELLS would deliver a lecture on "**The Art of Camouflage.**"

LAMBERT AND PHOTOMETRY.

By ALEXANDER PELHAM TROTTER (*President*).

(Abstract of an Address delivered at the meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 5.30 p.m., on Tuesday, November 25th, 1919.)

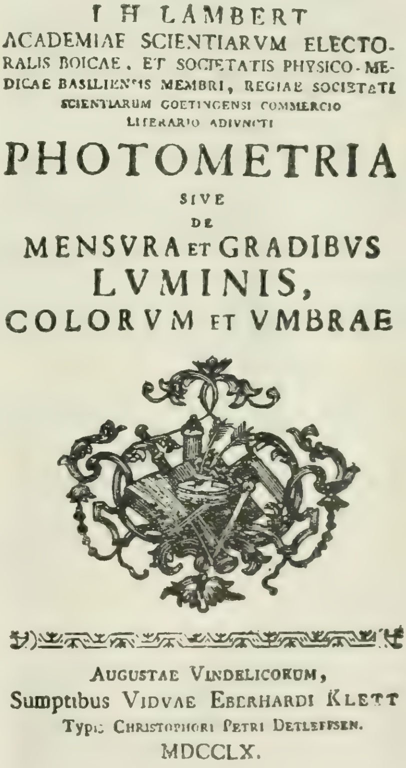
LAMBERT, born in 1728, the year that Newton died, at Mulhausen, then a town in Switzerland, contemporary with Galvani, Lagrange and D'Alembert, was one of the most versatile and prolific scientific writers of the eighteenth century.

His father was a French refugee after the revocation of the edict of Nantes. French biographers, giving him the names Jean and Henri, appear to claim him as a Frenchman, but he seems to have lived in Germany in middle life, and German writers call him Johann Heinrich Lambrecht.

At the age of 20 he became tutor to the sons of Count de Salis of Coire in Switzerland, and he had access to a good library. He travelled in western Europe with his pupils, and settled in 1759 for a few years at Augsberg. At the age of 36 he published at Utrecht an essay on refraction : *Dissertation sur les proprietés remarquables de la route de la lumière par les airs et en général par plusieurs milieux refringentes.* This work, says one of his biographers, falling later into the hands of Arago, caused him to follow the way opened by his predecessor in this investigation. Soon after the publication of this work Lambert moved to Berlin.

French, German, Latin, and Greek were all familiar to him. In 1759 he published a book on perspective in French, and *Photometria* in Latin in 1760, and this was followed by an amazing number of papers of the Berlin Academy on physical, astronomical, and mathematical subjects, among which may be mentioned *Pyrometria*, a treatise on heat, and a memoir on infinite series, developed afterwards by Euler and Lagrange. He introduced hyperbolic functions into trigonometry and gave an important theorem on planetary motion.

He was a man of medium height, simple in manner and absent-minded. "*Sa physionomie était douce, prevenante et spirituelle.*" He loved discussion, and when once started on an argument, whatever it might be, it was not possible to interrupt him.



I H LAMBERT
ACADEMIAE SCIENTIARVM ELECTO-
RALIS BOICAE . ET SOCIETATIS PHYSICO-ME-
DICAE BASILIENSIS MEMBRI, REGIAE SOCIETATI
SCIENTIARUM GOETINGENSI COMMERCIO
LITERARIO ADIVNCTI
PHOTOMETRIA
SIVE
DE
MENSVRA ET GRADIBVS
LVMINIS,
COLORVM ET VMBRAE

AUGUSTAE VINDELICORUM,
Sumptibus VIDVAE EBERHARDI KLETT
Typis CHRISTOPHORI PETRI DETLEFFSEN.
MDCCLX.

Title page of Lambert's *Photometria.*

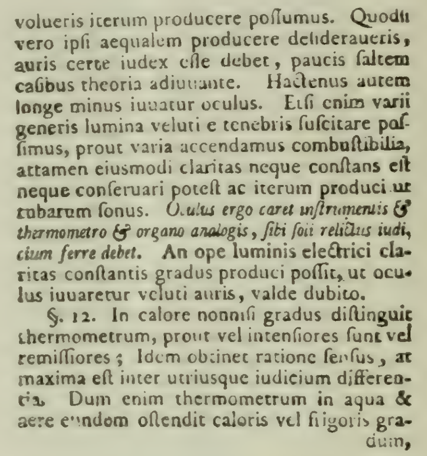
The title-page of *Photometria* is in Latin, but half of the preface is in French. He refers in it to the work of Newton and of Euler, and to the optical researches of Smith and Kaestner. He alludes to the excellent *Essai d'Optique sur la Graduation de la Lumiere* of Bouguer (published in 1729, the year after Lambert was born), but he does not mention Bouguer's memoir on "Means for Measuring Light and some Applications of those Means," published in 1757, nor the '*Traité d'Optique*,' published 1760, two years after Bouguer died. If he had seen these he would not have lamented the non-existence of a photometer.

On page 5 of *Photometria* he says that it is greatly to be wished that a photometer should be "excogitated," analogous to a thermometer, which would indicate the intensity and brightness of a light exposed to it. He dwells on this for four pages and on page 6 says that in estimating the graduations of light the eye alone is the judge. On page 8 he says that while we can reproduce any given sound with musical instruments, and though light of various kinds can be produced by flames, we cannot obtain a light of constant brightness and reproduce it like the note of a trumpet. Then he adds, in italics, "The eye therefore lacks instruments like the thermometer or organ, so that when left to itself it might give judgement." On page 16 he makes a statement which is the foundation of all photometry, namely, that in estimating degrees of brightness no ratio is of value except that of equality.

After 23 pages of very interesting introduction, he prepares for work by giving three "primary notions."

1. Two or more candles give more light than one.
2. An object moved nearer to a light becomes brighter.
3. Light falling at an angle on a surface illuminates it less.

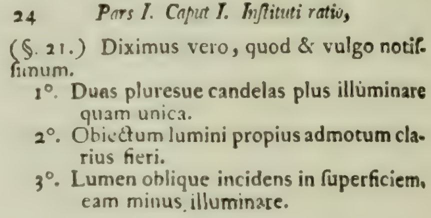
On the next page he states the law of the squares of the distance, and on page 27, the celebrated law connected with his name, Lambert's cosine law, and proves it with his first diagram. Like other Continental writers of this period* he took the inclination of the ray with the surface as the angle of incidence, and therefore wrote "sine" instead of "cosine." "The normal illumination will be to the oblique illumination as the whole sine is to the sine of the angle of incidence." Modern writers who have not read Lambert's work are disposed to attribute to him,



volueris iterum producere poſſumus. Quodſi vero ipſi aequalem producere deſideraueris, auris certe iudex eſſe debet, paucis ſaltem caſibus theoria adiuuante. Hactenus autem longe minus iuuatur oculus. Etſi enim varii generis lumina veluti e tenebris ſuſcitare poſſimus, prout varia accendamus combuſtibilia, attamen eiusmodi claritas neque conſtans eſt neque conſeruari poteſt ac iterum produci ut tubarum ſonus. *Oculus ergo caret inſtrumentis & thermometro & organo analogis, ſibi ſoli relictus iudicium ferre debet.* An ope luminis electrici claritas conſtantis gradus produci poſſit, ut oculus iuuaretur veluti auris, valde dubito.

§. 12. In calore nonniſi gradus diſtinguit thermometrum, prout vel intenſiores ſunt vel remiſſiores; Idem obtinet ratione ſenſus, at maxima eſt inter utriusque iudicium differentia. Dum enim thermometrum in aqua & aere eundem oſtendit caloris vel frigoris gradum,

Extract from Lambert's *Photometria* (p. 8).

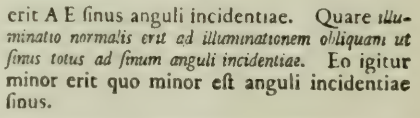


24 *Pars I. Caput I. Inſtituti ratio,*

(§. 21.) Diximus vero, quod & vulgo notiſſimum.

1°. Duas pluresue candelas plus illuminare quam unica.
2°. Obiectum lumini propius admotum clarius fieri.
3°. Lumen oblique incidens in ſuperficiem, eam minus illuminare.

Extract from Lambert's *Photometria* (p. 24).



erit A E ſinus anguli incidentiae. Quare *illuminatio normalis erit ad illuminationem obliquam ut ſinus totus ad ſinum anguli incidentiae.* Eo igitur minor erit quo minor eſt anguli incidentiae ſinus.

Extract from Lambert's *Photometria* (p. 28) (enunciating Lambert's Cosine Law).

---

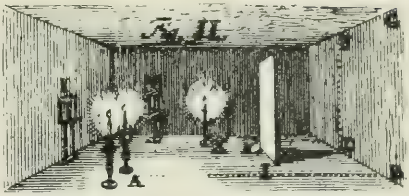
* The earliest writers, such as Snell and even the Greek writers, considered refraction as the deflexion of a ray, and measured the angle with the ray, and hence with the normal. Jacob Gregory, one of the earliest English writers in 1663, followed this usage. Newton in his *Optics* in 1704, in his *Principia* in 1726, and Robert Smith in 1738, referred angles of incidence to the normal. The change seems to have been made by Descartes, whom Continental writers seem to have followed for a time.

and to expand his law to cover, all cases in which the cosine function appears in the theory of illumination, and a recent book on searchlights suggests that Lambert's law explains the distribution of light from the electric arc.

Experiment I. is illustrated by his second figure. Two candles equally bright are placed at A, the light falling normally on the white wall or paper BGFD. A narrower plane, HI, is set so that the shadow of the candles at A falls on the wall, DFEC. A third candle at K is moved towards or from the wall BE, until the parts D, DG and DE are seen to be equally illuminated. This being done, the distance of the candles from the wall is measured, and AB will be to KC as $\surd 2$ is to 1, or by inverting, the square of the distance KC as 2 to 1.

It is very remarkable (at least so I understand him) that having made this experiment, or even having conceived it from his mathematical knowledge, he should not have recognised that it afforded a means for measuring light. The question remains: did he or did he not invent a photometer? I am inclined to think, in spite of the title of his great work, that he did not, and that Bouguer was the first man to measure light. In the index to *Photometria* there are two references to *instrumenta photometrica*, but these relate to experiments with colours and not to anything like a photometric instrument.

It is probable that before his death in 1778 he had heard of Bouguer's photometer, which is to-day the official instrument used by the Metropolitan Gas Referees. It is to be regretted that *Photometria* has not been translated into English or French.



Illustrating Lambert's experiments with candles (from the *Photometria*), demonstrating the Inverse Square Law.

Obituary.

S. D. CHALMERS.

WE note with great regret the death of, at the early age of 42 years, Mr. S. D. Chalmers on Friday, November 7th. Mr. Chalmers was a member of the Illuminating Engineering Society from its early stages and took part in many of its discussions. He was also closely associated with the Optical Society of London, of which he was at one time President. He did excellent work as Head of the Department of Technical Optics at the Northampton Institute, and in many directions he exerted himself on behalf of the optical industry in this country. During the war he undertook much important testing work on optical appliances and was also responsible for the organisation of a special workshop in which girls were trained in the grinding and polishing of lenses needed for optical munitions. His untimely death, to which allusion was made by the President at the meeting of the Illuminating Engineering Society on November 25th, will be the subject of general regret.

NOTES ON EVENTS DURING THE VACATION.

By L. GASTER, *Hon. Secretary.*

(Presented at the meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., at 5.30 p.m. on Tuesday, November 25th, 1919.)

THE co-operation of these various bodies will doubtless be most helpful in dealing with problems of mutual interest, and affords a recognition of the standing of the Society and its impartial mode of work. As announced at the Annual Meeting the Society has now been added to the list of constituent bodies of the Conjoint Board of Scientific Societies, and through the medium of its President, is taking part in the work of this body.

It is customary at the first meeting of the session to give some account of progress during the vacation.

The arrangement whereby the Presidents of the Institutions of Gas and Electrical Engineers become Vice-Presidents and Members of Council during their tenure of office has now been extended to a number of other bodies, and the institutions whose acting Presidents become Members of Council are now as follows :—

The Illuminating Engineering Society in the United States ; the Illuminating Engineering Society in Japan ; the Institution of Gas Engineers ; the Institution of Electrical Engineers ; the Council of British Ophthalmologists ; the Ophthalmological Society ; the Physiological Society ; the Electrical Contractors Association ; and the Association of Railway Electrical and Telegraph Engineers.

The National Illumination Committee has now resumed its work, the Chairman being the President of the Illuminating Engineering Society, while its Hon. Secretary is one of the two representatives on the Executive Committee of the International Commission on Illumination. There is much useful work awaiting the Committee and it is to be hoped that international consideration of these problems will now be resumed.

While, as usual, no meetings have been held during the vacation, the Society has been actively engaged through its various committees.

Three of the new committees have now been provisionally constituted and have commenced work, namely, those on Progress in Lamps and Lighting Appliances, Eye-strain in Cinemas, and Railway Lighting. These Committees are constituted as follows :—

Joint Committee of Enquiry on Eye-Strain in Cinema Theatres and its Prevention.

Mr. A. Blok, Asst.-Prof. W. C. Clinton, Mr. J. S. Dow, Mr. L. Gaster (Secretary), Mr. F. W. Goodenough, Mr. Haydn T. Harrison, Prof. J. T. McGregor Morris, representing *The Illuminating Engineering Society.*

Col. J. H. Parsons, C.B.E. (Chairman), Mr. Stephen Mayou, Mr. W. H. McMullen, O.B.E., and Mr. Bernard Gridland, representing *The Council of British Ophthalmologists.*

Prof W. M. Bayliss, Dr. W. MacDougall, Prof. C. S. Sherrington, Prof. C. Spearman, representing *The Physiological Society.*

Mr. E. Ridley (*Inspection Dept., London Fire Brigade, L.C.C.*), Dr. James Kerr (*Medical Research Officer, Public Health Dept., L.C.C.*), (Deputy Chairman), Dr. C. W. Kimmins (*Chief Inspector, Education Officer's Dept., L.C.C.*).

Mr. F. G. Goodwin, Mr. A. E. Newbould, Mr. J. W. Barber, representing the *Cinema Industry.*

Joint Committee on Railway Lighting.

Lieut.-Col. F. A. Cortez Leigh (London and North Western Railway), Chairman, Mr. J. S. Dow, Mr. L. Gaster, Mr. F. W. Goodenough, Mr. A. Stokes, Mr. A. Cunnington (London and South Western Railway), Secretary, representing the *Illuminating Engineering Society.*

The following have also consented to act on the Committee :—Mr. Roger T. Smith (Great Western Railway) and Mr. W. Wood (North British Railway), who are Members of the *Association of Railway Electrical and Telegraph Engineer ;* Mr. A. R. Cooper (Underground Railways), and Mr. W. S. Goodchild (Midland Railway).

Committee on Progress in Lamps and Lighting Appliances.

Electric :—

Mr. S. H. Callow (Chairman), Mr. J. E. Edgecombe, Mr. J. W. Elliott (Secretary), Mr. J. Y. Fletcher, Mr. F. W. Willcox.

While it is naturally only possible to refer in the most general terms to the actual work of these Committees at present, it may be said that there are in all cases prospects of useful work.

An interim report on the Present Position in regard to Electric Incandescent Lamps and Fittings is presented at this meeting by the Committee on Progress in Lamps and Lighting Appliances.

It was felt that this Committee would prove valuable in providing a link with makers of lamps, fittings, etc., so that any developments or special problems could be brought to the notice of the Society ; the Committee has power to add to its members as occasion arises. The Committee on Railway Lighting has already held several meetings and is engaged in mapping out the method of work in order to obtain measurements of illumination on some of the chief railways on a uniform basis. The Joint Committee on Eye-strain in Cinemas has likewise met and divided its work among suitable sub-committees, by whom visits to cinemas for the purpose of collecting data on visual effects and conditions of illumination are being made.

It will doubtless be recalled by members that a list of these committees was given in the August issue of the Journal, which also contained a survey of the work of the Society during its first ten years of existence. This section of the Journal has now been reprinted in pamphlet form and will, it is hoped, be useful in approaching those outside the Society and adding to its membership.

An event of interest during the Vacation was the second British Scientific Products Exhibition, which was held at the Central Hall, Westminster, on July 3rd to August 5th, 1919, and it is gratifying to observe that this exhibition is to be an annual feature. The Society was again represented on the sub-committee to which matters of illumination were referred, and its Hon. Secretary delivered a lecture on "Scientific Lighting and Industrial Efficiency" in which the necessity for proper methods of lighting in factories was strongly emphasised.

Several other important exhibitions have recently taken place in London, and, with the removal of war restrictions, will doubtless be held more frequently in the future. The lighting of such exhibitions on a uniform plan is a matter that deserves serious attention ; in many cases correct principles of lighting are not followed by exhibitors, and the appearance of the stalls is prejudiced thereby.

It is hoped that, now that the distractions of the war are at an end, the Departmental (Home Office) Committee on Lighting in Factories and Workshops will shortly be resumed, and that in the near future its recommendation that definite requirements as regards industrial lighting will be introduced into the Factory Acts, and will be carried into effect. The matter will doubtless come up for consideration in other countries. The moment seems opportune for the treatment of industrial lighting on a common basis by all the chief nations of Europe. Meantime the Report of H.M. Chief Inspector of Factories for 1918 contains some useful remarks on the importance of adequate industrial lighting in the interests of safety, health, and efficiency of work.

In the Annual Report of the Council presented in June last, attention was drawn to the fact that five States in America have now adopted legislative codes on industrial lighting. At a recent meeting of the Illuminating Engineering

Society in that country some particulars were given of the results already obtained in the State of New York. It appears that no difficulty is being experienced in the working of the code and that during the period August, 1918, to February, 1919, about 50 per cent. of compliances with orders for improved illumination have been secured. Great importance is attached to educational facilities to enable inspectors and managers of factories to appreciate the requirements of good lighting, and for this purpose courses of lectures, demonstrations, etc., have been arranged.

In particular attention has been devoted to the importance of good industrial lighting in the interests of safety. At an exhibition recently arranged by the National Lamp Works at Cleveland, U.S.A., a feature was the exhibit of industrial lighting, a model shop being shown fitted with three installations illustrating poor, average, and good lighting, which could be switched on in succession. It is anticipated that this aspect of the subject will receive special attention from the British Industrial Safety Association in this country, which proposes to issue shortly a pamphlet emphasising the value of good illumination in relation to safety.

A series of important resolutions relating to the new system of rating gas in terms of potential thermal units were passed at the Conference of Gas Standards held at the Institution of Civil Engineers on October 28th. The question is one of great interest to the Society and will, it is hoped, be the subject of discussion in the near future.

Great interest is being shown in matters of illumination by students and it would appear that the moment is opportune for arranging courses of lectures on the subject at leading colleges, resuming the practice initiated by the Society at several educational institutions in London a few years ago. One of the members of the Society, Mr. W. C. Clinton, delivered a public lecture at University College, London, on Oct. 24th, on "Recent Developments in Public and Private Lighting," and it will be recalled that earlier in the year a paper on "The Principles of Scientific Illumination" was read before the Students' Section of the Institution of Electrical Engineers by Mr. C. E. Webb, the Hon. Secretary of the Society presiding.

During recent months a considerable amount of attention has been devoted to lighting matters in the press, and articles on such subjects as office and factory lighting have been furnished to several journals.

Some particulars of the development of the Illuminating Engineering Society in Japan have recently been furnished by Mr. M. Uchisaka, who has been on a visit to this country in connection with the Electrotechnical Congress. These data have been published in the official journal. It is gratifying to observe that the movement in Japan is making good progress, and there should be opportunities for closer co-operation between the two societies.

JOINT COMMITTEE ON RAILWAY LIGHTING.

At the conclusion of the above address Lieut.-Colonel F. A. Cortez Leigh, Chairman of the Joint Committee on Railway Lighting, gave a brief account of the constitution and aims of this Committee. He recalled that the Society had dealt with the subject about eight years ago, and again on the occasion of the paper read by Mr. A. Cunnington in February in the present year. These discussions revealed a number of outstanding points on which fuller information was needed, and the Society had accordingly formed a Joint Committee, on which members of the Society and railway engineers were represented, to carry out a survey of lighting conditions on the chief railways in this country. As a result of systematic tests it was hoped to establish some general principles which would be of great value to the various railway companies as well as to the general public. The Committee were at present engaged in mapping out their procedure and arranging the basis on which tests should be made.

THE POSITION OF THE METAL FILAMENT LAMP AND FITTINGS INDUSTRY AT THE PRESENT TIME.

(Report by the Committee on Progress in Lamps and Lighting Appliances (Mr. S. H. Callow (Chairman), Mr. J. E. Edgecombe, Mr. J. W. Elliott (Secretary), Mr. J. Y. Fletcher, and Mr. F. W. Willcox); presented at the meeting of the Society held at the House of the Royal Society of Arts (18, John Street, Adelphi, W.C.), at 5.30 p.m. on November 25th, 1919.)

Metal Filament Lamps.

It may confidently be stated that the situation as regards adequate supplies of incandescent electric lamps in this country is now rapidly improving.

During the war, and for a considerable period after the Armistice, it must be admitted that the supply of lamps for other than Government requirements was entirely inadequate, but with the reduction of the Government's demands, together with some increase in the output of the factories, due to the return of skilled workers and more normal conditions pertaining, the supply has rapidly approached the normal, and it is considered that the production of lamps in this country is approximately equal to the consumption.

It is, of course, quite true that delivery from stock of any particular type of lamp cannot often be obtained, but this is due to the fact that although the supply is approximately equal to the demand up to the present the manufacturers have been unable to accumulate adequate stock in addition to meeting the demand.

This should, however, right itself within the next six months.

As regards the question of bulbs and glass generally for the manufacture of electric lamps, the situation is still unsatisfactory, as is shown by the fact that a certain number of bulbs have had to be imported.

It is considered, however, that in the near future the whole of the demands of the lamp manufacturers for such bulbs and glass will be met by production within the country, largely due to the adoption of automatic machinery for making bulbs and tube.

With reference to drawn tungsten wire for filaments, there are adequate supplies, and this is also the case as regards the variety of gases used in a modern incandescent lamp factory.

During the war, it was practically impossible to obtain argon (which is necessary for the manufacture of the lower wattages of gas-filled lamps) in this country. This difficulty has now been overcome and adequate supplies are available.

It is, of course, anticipated that in the near future when the new scheme of house building begins to come into operation, the demand for metal filament lamps will greatly increase. The manufacturers, however, have every hope that they will be able to cope with this increased demand, and that no shortage in the supply of lamps need be anticipated.

With reference to prices, a very considerable reduction (approximately 20 per cent. all round) has already been made in the price of gas-filled lamps, and as soon as manufacturing facilities permit, there is no doubt that a reduction will also be made in the case of other types.

Fittings.

With reference to the supply of suitable fittings scientifically designed, it is admitted that the situation has not been satisfactory, and this is particularly the case as regards fittings for use in conjunction with gas-filled lamps.

Since the Armistice, however, most of the leading manufacturers have been engaged on the designing and manufacture of suitable lanterns for use with such lamps, particularly for the lighting of streets, railway termini, factories, public buildings or other large areas.

One of the great difficulties, however, has been to obtain the necessary globes

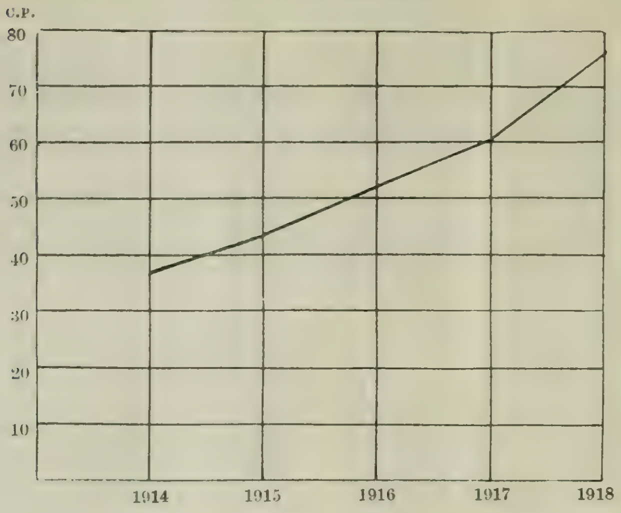


FIG. 1.—Average candlepower demand; both vacuum and gas-filled lamps. During war period.

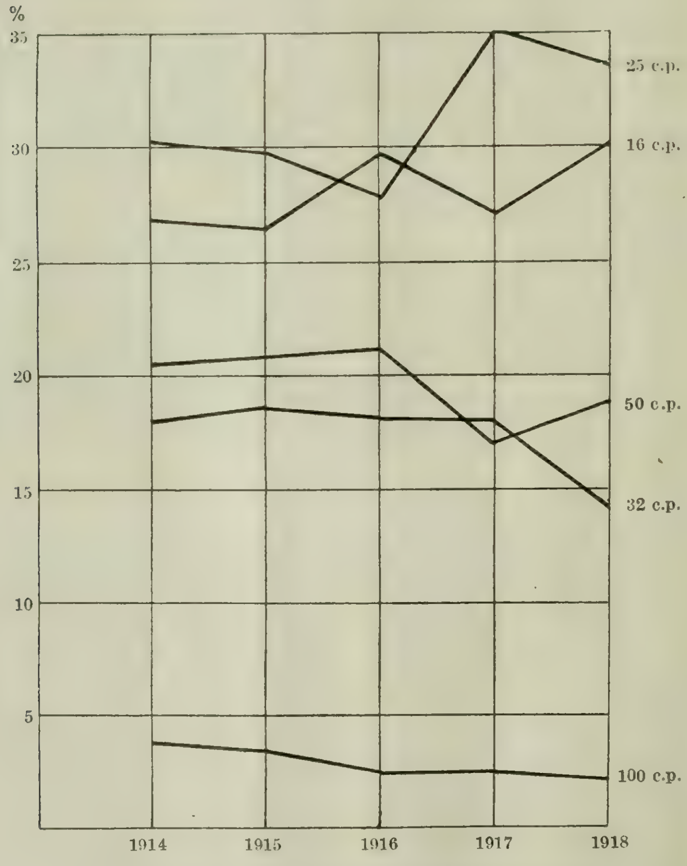


FIG. 2.—Annual demand for various candlepowers; vacuum lamps only. During war period.

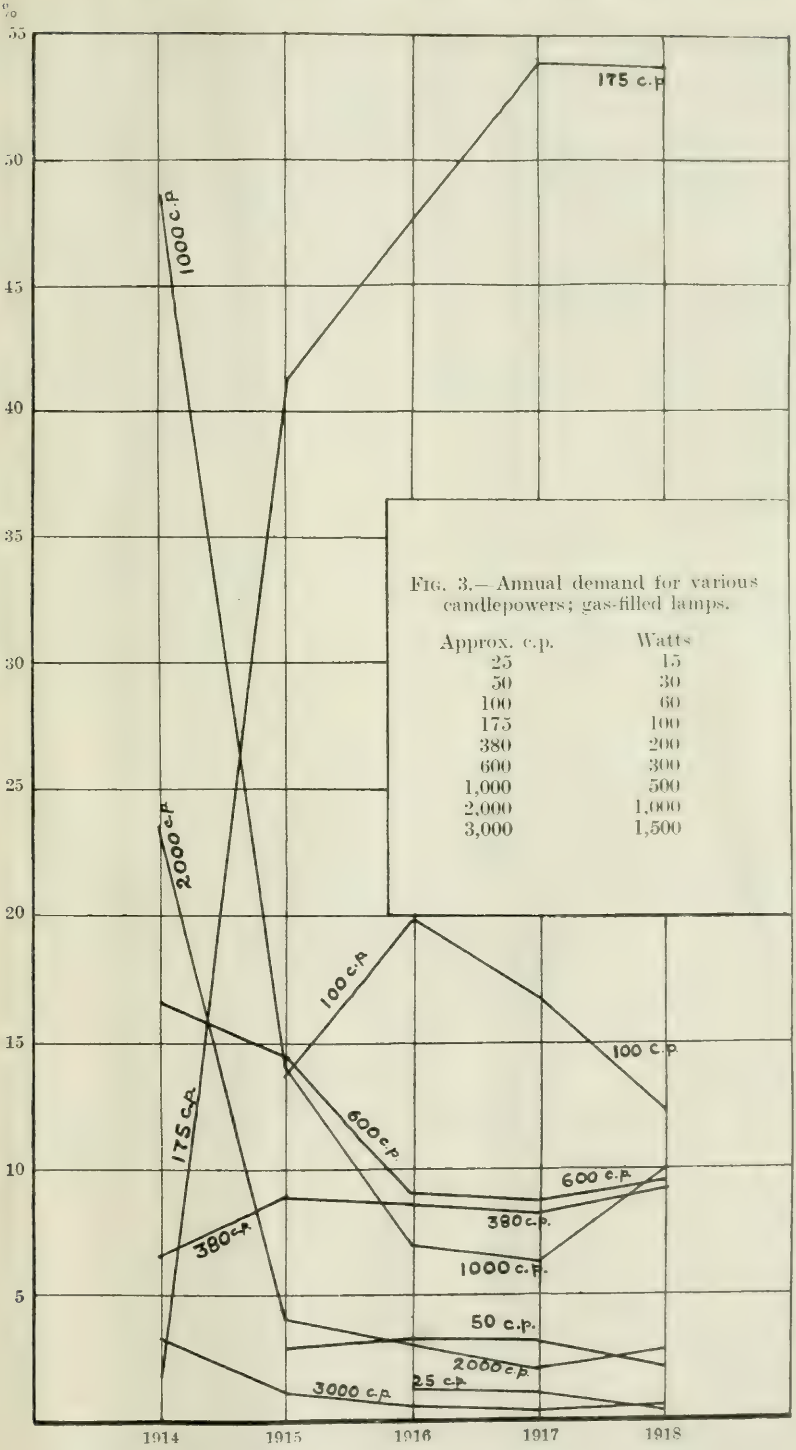


FIG. 3.—Annual demand for various candlepowers; gas-filled lamps.

Approx. c.p.	Watts
25	15
50	30
100	60
175	100
380	200
600	300
1,000	500
2,000	1,000
3,000	1,500

for use therewith, and so far the supply of English-made globes has been entirely inadequate to meet demands, and it has therefore been found necessary to import a certain number.

This matter is still in hand, however, and the Committee would like an opportunity of reporting again on the subject at a later date.

During the past 12 months, smaller sizes of half-watt type lamps have come into general use, particularly for shop-window lighting, etc., and it is very much regretted that at the present time there is not a supply of scientific fittings or reflectors suitable for use therewith.

This matter is, however, engaging the attention of the leading manufacturers, and it is hoped that in the near future supplies of suitable articles will be available.

Here, again, the inadequate production of glassware in this country has mitigated against rapid progress.

With reference to the question of the average annual demand for various candlepowers, a set of curves is presented, showing the annual demand for each candlepower, both vacuum type and gas-filled, for the past five years, also a set of curves showing the average annual candlepower demand.

ARTIFICIAL DAYLIGHT. (See p. 323.)

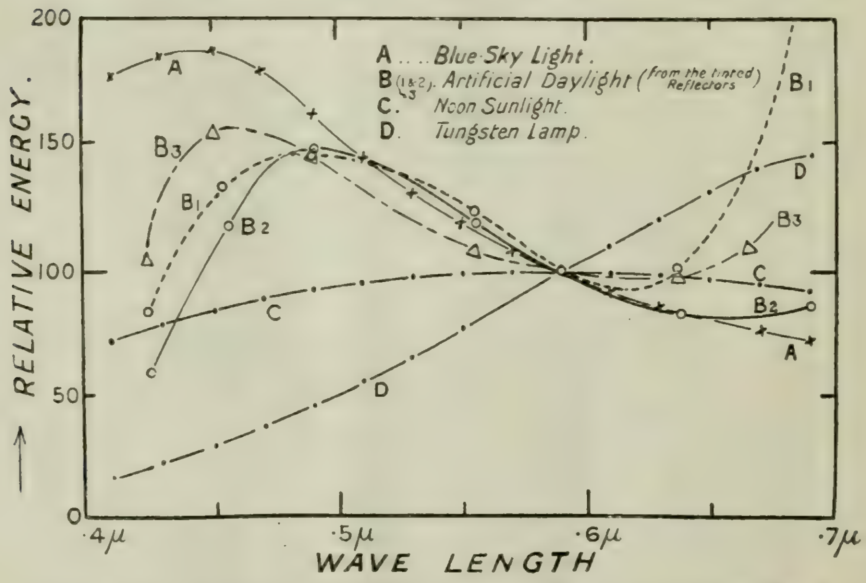


FIG. 2.—Showing distribution of energy throughout the spectrum from A. Blue Sky, B (1, 2 and 3), Artificial Daylight, C, Noon Sunlight, and D, Tungsten Lamp.

RECENT DEVELOPMENTS IN ILLUMINATING ENGINEERING.

(Exhibits shown at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 5.30 p.m., on November 25th, 1919.)

THE SHERINGHAM DAYLIGHT.

Exhibited by L. C. MARTIN,

Lecturer in the Technical Optics Department, Imperial College of Science and Technology.

THIS lamp or lamp attachment makes use of a coloured reflector for correcting the distribution of energy in the spectrum of the artificial source. It was originally founded on the invention of Mr. G. Sheringham, the well-known artist, who used simple coloured reflectors or shades with artificial sources and found the quality of the light for painting immensely improved. The possibilities of the system have been to some extent worked out by the present exhibitor, the requisite distribution of colours being calculated on spectro-photometric measurements on opaque pigments made by means of Abney's colour-patch apparatus. It is necessary in general to make use of arrangements to reflect the whole of the light from the coloured surface, thus producing a type of indirect lighting unit which should have great possibilities in connection with shop window lighting and many other commercial and industrial uses. It is hoped to make the lamp the subject of a communication to the Society in the near future, and an exhibition of this and certain modified units is also to be held.

The curves for certain of the reflectors are illustrated in the diagram herewith. These represent attempts to obtain the highest possible correction (blue sky light). The curve B3 has been found possible by the use of a new violet dye brought to my notice since the meeting. It makes possible a great improvement on the previous attempts. Approximate calculations indicate that the luminous efficiency obtainable is roughly the same as that of the transmission units which give an equivalent correction. Sunlight units of much higher luminous efficiency can easily be arranged by introducing white areas into the reflector.

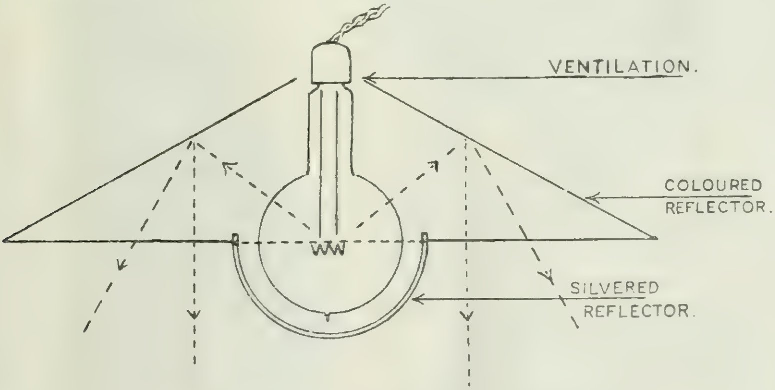


FIG. 1.—Diagram of Sheringham Daylight Lamp.

EXHIBIT OF "POINTOLITE" LAMPS

Demonstrated by P. FREEDMAN, of the Ediswan Laboratory.

THE exhibits included an ordinary 100 candlepower lamp, a fixed focus 100 candlepower lamp, a 30 candlepower lamp, 500 and 1,000 candlepower lamps, special low voltage 100 candlepower lamps, 100 and 500 candlepower lamps with glass deflectors, a special pyrometric lamp, fused tungsten electrodes, etc. A new 4,000 candlepower lamp, now in course of development, was also shown for the first time.

The history of the development of the lamp since 1915 was briefly outlined.

Two distinct types of "pointolite" lamps have been developed. The two-electrode type, which was the first to appear, and which is still adopted for lower candlepowers and for special pyrometric lamps; and the three-electrode type, more recently developed and adopted for higher candlepowers. Both types are designed to work only on D.C. or rectified A.C.

The two-electrode lamp consists essentially of a +ve electrode in the form of a tungsten globule mounted on a tungsten stalk and a −ve electrode, known as the ioniser, in the form of a special filament mounted on two molybdenum leads sealed in a glass bulb filled with nitrogen at a low pressure.

The +ve electrode is electrically connected through a suitable resistance to the +ve pole of the supply. One end of the ioniser is electrically connected to the −ve, the other end through a push switch and a suitable resistance to the +ve pole of the supply.

When the push switch is closed current flows through the ioniser, which incandesces and ionises the gas in its vicinity. On the push switch being released, a condition is obtained favourable to the formation of an arc,—mainly involving a pre-heated −ve electrode, a +ve electrode and a gas between these ionised by the hot body and further ionised by collision.

The arc is accordingly formed and maintained between the globule and the ioniser, the globule becoming brightly incandescent and acting as a point source of light.

The three-electrode lamp resembles the two-electrode type, but has in addition to the globule and the ioniser, a third electrode in the shape of a tungsten plate mounted on a tungsten stalk. At first the arc is formed between the ioniser as −ve and the globule as +ve electrode, the plate electrode being dead. Then, by means of suitable switch gear, the ioniser is made dead, the incandescent

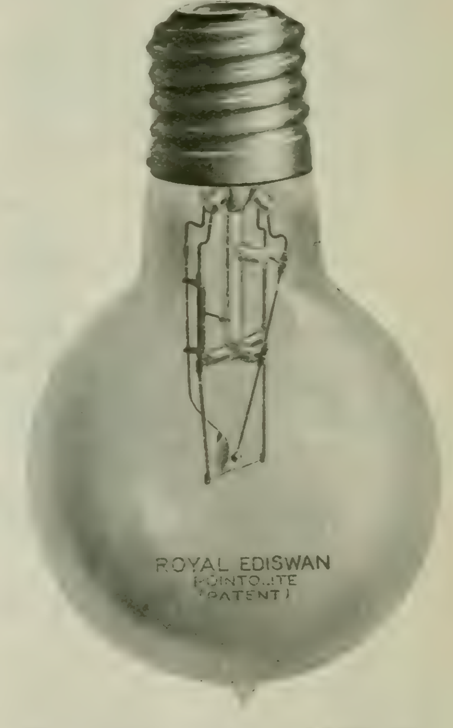


FIG. 1.—General appearance of "Pointolite" 3-electrode lamp.

globule is made a – ve electrode and the plate the new +ve electrode, the arc being formed between these. In this type of lamp most light comes from the incandescent plate electrode, but the incandescent – ve electrode also furnishes an appreciable light.

The first 100 candlepower pointolite lamp was exhibited before the Society in December, 1915. In the two following years considerable progress was made, notably in the design of ionisers. The original ionisers were either solid rods of the same material threaded with fine tungsten wire, or tubes composed of a mixture of tungsten and certain refractory oxides, and had the defect of tending to become distorted after comparatively few switchings on and off of the lamp. "Composite" types, consisting of a tungsten wire partly straight and partly spiralised and of a tube of ioniser mixture threaded over the straight part of the wire, have been substituted. The arc was struck on the spiral portion, and then passed on to the tubular portion of the ioniser. The new ioniser has proved very satisfactory, having a much longer life than the old type.

A 30 candlepower lamp similar to the 100 candlepower variety but of smaller dimensions has also been designed.

The three-electrode 500 c.p. lamp, first experimented with in 1915, owes its success partly to the new form of ioniser and partly to an improved type of electrode. The plate is strong mechanically, and a life of 250 hours at a specific consumption of 0·5 watts per candle was obtained.

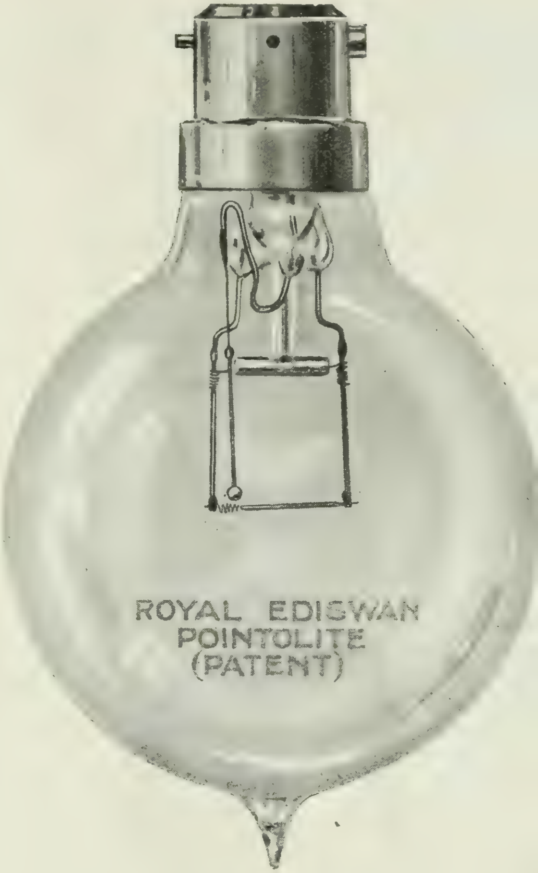


FIG. 2.—General appearance of 2-electrode "Pointolite" lamp.

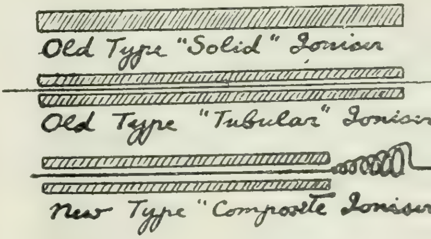


FIG. 3.—Showing details of old and new form of Ioniser.

The year 1918 was devoted mainly to improvements in various details, *e.g.*, in the method of exhausting the bulb, and in the commercial production of ioniser, filaments and electrodes. Work was, however, hampered by lack of materials. Nevertheless a series of experiments on the production of larg globules met with success.

In 1919 considerable progress ha been made. A new method of globul manufacture enables very large globule to be mounted on the same size of stal as formerly, thus facilitating the production of lamps of much higher candlepower. Thus a globule 0·25 inches in diameter can be mounted on a stalk 0·035 inches in diameter, and a hemispherical electrode of fused tungsten 1 cm. in diameter or more can be used.

The special hemispherical electrode is used in the new "pyrometric" two-electrode 100 c.p. lamp. The arc is struck on the curved part of the hemispherical electrode, the flat fused back of which then presents a uniformly luminous surface 1 cm. in diameter, whose brightness can be varied from orange to brilliant white, the range of temperature available being 1,200° C.–1,300° C. to 2,500° C.–2,800° C. This renders the lamp very suitable for pyrometric work, as a comparison "hot body," and it is now being used by the N.P.L. for various pyrometric calibrations.

The ability to make larger globules also led to the production of the 1,000 candlepower lamp, which generally resembles the 500 candlepower type, but has somewhat larger electrodes. The enclosing bulb is 6 inches in diameter, the specific consumption 0·42 watts per candlepower, and the life about 250 hours. The lamp was designed primarily for cinematograph work, for which its steadiness and ease of manipulation and the cooler beam are distinctly advantageous.

The candlepower, however, hardly appeared sufficient for projecting for long distances, and ultimately a 4,000 candlepower lamp has been developed for this purpose. This lamp, at present in the experimental stage, has given very promising results. It is similar in construction to the 500 and 1,000 candlepower lamps, but has very large electrodes, the globule being 0·25 inches in diameter and the plate having a 0·5 inch edge. The enclosing bulb is eight inches in diameter. The probable efficiency which will be practicable with this lamp is about 0·26 watts per candle and the probable life attainable with this efficiency about 250 hours.

A number of experiments with "pointolite" lamps filled with gases other than nitrogen have resulted in the production of lamps of much lower arc voltage than that previously obtainable. Thus the argon-filled 100 candlepower lamps can be successfully operated on 30-volt circuits, and certain types have been operated on even lower voltages. This enables the "pointolite" lamp to be used with small portable accumulator sets.

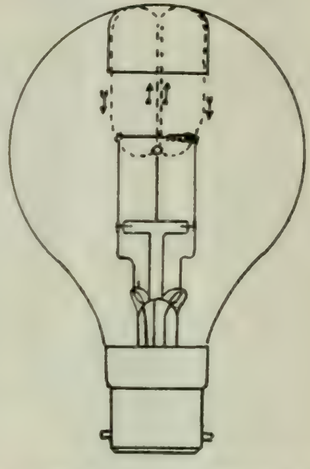


FIG. 4.—Diagram of device to obviate blackening. Arrows show path of connection currents.

A device has also been developed for increasing the life of "pointolite" lamps by eliminating blackening of the bulb. This device involves the use of a glass cap near the pip, forming a dome above the arc and electrodes when the lamp is run pip-upwards. Convection currents strike the top of the glass dome and are guided down the sides of the bulb back into the arc. The closed cycle of convection currents thus established keeps the bulb clean, the blackening being concentrated in the glass cap, and prolongs the life of the tungsten electrodes, owing to the fact that volatilisation is checked by the latter being in an atmosphere more or less saturated with tungsten particles.

The special uses of these lamps are numerous. During the war 100 candlepower lamps of the fixed focus type have been largely used with parabolic reflectors as signalling searchlights. Both the 100 candlepower and 500 candlepower types have proved suitable for lanterns, while for cinematographs the 1,000 candlepower and 4,000 candlepower have promising possibilities. The lamps are used for microscopic illumination and the study of the micro-structure of metals, for surgical fittings used on the operating table, and for galvanometer and oscillographic work. Lamps have also been used in conjunction with optical apparatus for the shadow-projection of gauges at Woolwich and elsewhere. The application of one special form of lamp for pyrometric work has already been mentioned. Other special uses are in photography, colour-matching and in stage illumination. To some extent, when equipped with a quartz bulb, the lamps have also been used as source of ultra-violet energy

In regard to colour-matching and photography the white colour of the light is an advantage, while in any process involving projection of light the fact that the light is uniformly distributed over a relatively large surface is of great importance. In cases where continuity of operation during work is of great consequence, it is worthy of note that these lamps, owing to the substantial nature of the light-giving source, rarely fail suddenly. In general there is a gradual diminution in the light when the end of the useful life is in sight, thus giving ample warning that the lamp will require to be replaced.

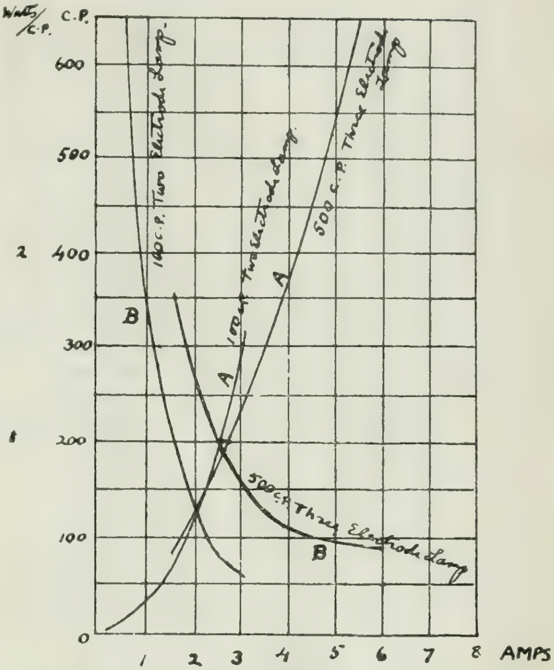


FIG. 5.—Characteristic curves for Pointolite Lamps.

Curve A. C.P.—Current Curve.
Curve B.—Watts/C.P.—Current Curve.

GAS-FILLED LAMPS WITH OPAL GLASS BULBS.

IN the course of the evening Mr. J. W. Elliott also exhibited another product of the Ediswan Laboratory, namely, a gas-filled lamp, of the ordinary type, but equipped with a bulb of opal diffusing glass. With a bulb of this type the filament itself cannot be seen and the light appears to be evenly spread over the surface of the bulb. While this necessarily involves some loss of light the use of such a bulb removes the difficulty of the high intrinsic brilliancy of the unshaded filament, and would enable the lamp to be used without a globe or screen in many situations where the glare would otherwise be highly inconvenient. On the other hand, in combination with suitable reflectors such lamps would give a pleasing effect. The making of bulbs of this type for gas-filled lamps was regarded as an interesting departure, which may have a distinct influence in some fields of illuminating engineering.

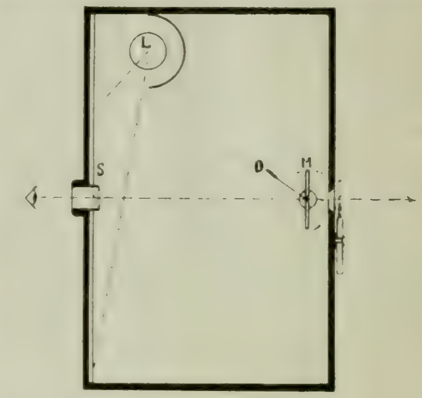
A NEW FORM OF ILLUMINATION PHOTOMETER

Exhibited by HAYDN T. HARRISON.

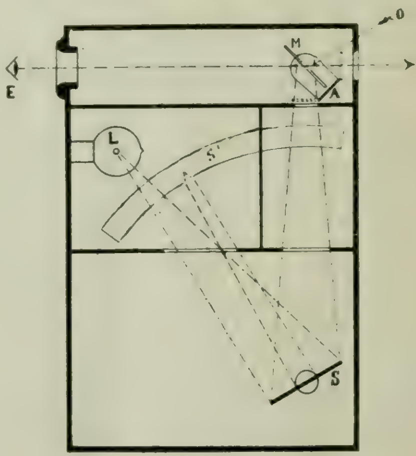
WHEN your President asked me to exhibit a portable photometer which I had devised in connection with my special work on Searchlights, I mentioned that I had only a laboratory-made rough model, but that I hoped to procure shortly a sample more worthy of exhibition before this Society. Unfortunately, due to the causes we all know so well, these finished instruments are not yet to hand; I must therefore apologise for exhibiting the roughly finished ones, which have both seen considerable use and proved very satisfactory for the purpose for which they were designed.

The first desideratum was to be able to read the indications without resource to external light, as so much of this work has to be done in comparative darkness, and an external light, such as a torch, is liable to spoil the dark accustomed condition of the eyes for photometric work. This object is obtained by using the light from the standard lamp. In type "A" the standard lamp, L, produces an illumination of descending grade on the screen, S, which is graduated in foot-candles. The operator views the scale, S, in the mirror, M, which has an aperture at O through which is viewed the screen which is illuminated by the light to be measured. The mirror, M, can be moved about its vertical axis and is turned by the operator until it reflects that part of the screen which balances with the external screen, when he can read off the actual marks and figures which he wishes to ascertain. In type "B" a translucent scale, S^1, illuminated by the standard lamp, is used, thus making the position of the pointer visible and easy to read when the balance has been obtained by the angular movement of the standard screens. This type "B" is very similar to the "Luxometer," as made by Messrs. Everett, Edgecumbe and Co., differing only in details. In developing these instruments I found that the method of comparing the illumination screens by means of a mirror having an aperture makes it possible to obtain a more perfect photometric balance than is the case with probably any instrument except the Lummer Brodhem.

The advantage of this arrangement is that there is no line of demarcation visible between the two screens as the thickness of the silver deposited is infinitely small and therefore invisible without considerable magnification. This causes the "photometric spot" to completely disappear when a balance is obtained with screens illuminated by lights of similar colour.



A



B

INDEX, November, 1919.

PAGE
Editorial, by L. GASTER 307

Illuminating Engineering Society—

(Founded in London, 1909)

Account of Meeting on November 25th, 1919 311
New Members 311
LAMBERT AND PHOTOMETRY. By A. P. TROTTER 313
NOTES ON EVENTS DURING THE VACATION. By L. GASTER 316
REPORT OF THE COMMITTEE ON PROGRESS IN LAMPS AND LIGHTING APPLIANCES 319
THE SHERINGHAM "DAYLIGHT." By L. C. MARTIN 323
NEW FORMS OF POINTOLITE LAMPS. By P. FREEDMAN 324
A NEW FORM OF ILLUMINATION PHOTOMETER. By HAYDN T. HARRISON 328
Obituary—S. D. CHALMERS 315
PUBLICATIONS RECEIVED 329

PUBLICATIONS RECEIVED.

Nature, Jubilee Number.

READERS will join us in congratulating *Nature* on attaining its fiftieth anniversary, an event which has been celebrated by the issue of a special "Jubilee Number." A series of congratulatory messages appears in the issue, many of them from the Presidents of leading scientific bodies, others from eminent men of science. Mr. A. P. Trotter, President of the Illuminating Engineering Society, is amongst those who thus mark their appreciation of the valuable work done by *Nature* during the past fifty years, and the Chairman of the Scientific and Technical Circle of the Institute of Journalists pays a tribute to its high authority on scientific matters and broad outlook.

Conquest. (Published by the Wireless Press Ltd., 12-13, *Henrietta Street, London.)*

THE first issue of this new publication, which aims at presenting scientific and technical matters in a readable form, promises well and contains several interesting articles. Mr. A. P. Burrows contributes an illustrated article on "Running the London Tubes." There is a description of the processes of production of a cinema film and an interview with Mr. Handley Page on the subject of "The Giant Aeroplane and its Future." Professor J. A. Fleming explains the application of oscillation and thermoionic valve-lamps in wireless telegraphy, and a sketch is given of the development of the incandescent lamp from Swan's original up to the latest gas-filled varieties.

Light in the Home. (Produced for the Electrical Development Association by the Industrial Publicity Service Ltd.)

THIS little booklet deals briefly with domestic lighting in an attractive and readable manner. Some sound hints on proper methods of lighting, explained by the aid of sketches and photographs of lighting installations, are given, and reference is made to the value of electrical appliances in lessening domestic work, and as a factor in rapid reconstruction. Such publications are most helpful in leading the public to appreciate the benefits of good lighting and to make the best use of the lamps and lighting appliances available, and in spreading abroad the principles established by the work of the Illuminating Engineering Society.

Bulletin of the Nela Research Laboratory of the General Electric Co. (U.S.A.).

WE have received a copy of the latest bulletin issued by the above laboratory, which contains abstracts of sixty-two researches published by members of the staff during recent years. The bulletin presents a record of a considerable amount of useful work. Many of the researches bear more or less closely on the physics of the incandescent lamp, but others deal generally with photometry, the effect of light on vision and other matters. Among the contributions we note a series of communications by Mr. M. Luckiesh on colour and the differences in hue of artificial illuminants and daylight. There are also several items dealing with ultra-violet light, its effect on vision and the design of protective glasses.

The Pathological Effects of Radiant Energy on the Eye. By F. H. Verhoeff and L. Bell. (Proc. American Acad. of Arts and Sciences, Vol. 51, No. 13, June, 1916.)

OUR attention has been drawn to the above comprehensive study which has just reached us from the United States. The complete volume occupies over 800 pages and appears to be one of the most complete studies of this subject yet published. Following the treatise by Drs. Verhoeff and L. Bell, a systematic review of literature on the subject is presented by Dr. C. B. Walker. The work constitutes an admirable example of co-operation between a pathologist and a physicist on the effect of light on vision.

Co-partnership Journal.

THE *Co-partnership Journal* for November contains some interesting notes on the early use of gas for illuminations in celebration of notable public events. The first instance on record appears to be the illumination of the Soho Works, Birmingham, of Matthew Boulton and James Watt in celebration of the Peace of Amiens in 1802, although candles were used on many much earlier occasions, notably the acquittal of the seven Bishops in 1688. An amusing account is also given of Winsor's proposals to use gas as a substitute for the wood-fire beacons, maintained in the early part of the last century, when the shadow of Napoleon still lay across Europe, and there was constant fear of invasion.

THE COLLEGE OF TECHNOLOGY, MANCHESTER.

Proposed Extensions.

WITH a view to the extension of the provision of university education in the Manchester District two appeals are being made to the public, one for £150,000 for an addition to the buildings of the College of Technology and the other for £500,000 for various purposes connected with the other departments of the same university. These extensions, which will practically double the accommodation for the undergraduates at the College of Technology and more than double the facilities for research, are urgently needed in view of the great demand for such education at the present time. It is common knowledge that many institutions are finding great difficulty in dealing with the large number of students desiring admission since the termination of the war, and it is in the national interest that this encouraging demand should be met.

It is pointed out that the sum asked for is small beside those being allocated for education and research at some of the American institutions. For instance Harvard University has collected an additional 12 million dollars during the last three months, and the Massachusetts Institute of Technology, 10 million dollars within one month, for the extension of their work.

RONTGEN SOCIETY

AN Exhibition of prints illustrative of the employment of the X-ray is being organised by the Rontgen Society, who have accepted an invitation of the Royal Photographic Society to provide a collection of such prints, to form an Exhibition at the Royal Photographic Society's House, 35, Russell Square, London, W.C., from January 6th to February 7th, 1920.

The Exhibition will be open daily (admission free) from 11 a.m. to 5 p.m., and on the evenings of January 6th and January 13th till 9 p.m. On the former date an elementary lecture on "The X-Rays approached from the popular standpoint" will be given by Dr. George H. Rodman, F.R.P.S., and on January 13th a discussion will be opened by Major G. W. C. Kaye, O.B.E., M.A., D.Sc., on "Some Aspects of Radiology." Both lectures will commence at 7 p.m.

The
ILLUMINATING
ENGINEER
·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·
Edited by
LEON GASTER
THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY LTD.,
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. 5215 Victoria.

EDITORIAL.

The Testing of Searchlight Carbons.

The war has had the effect of interesting many people in the various applications of searchlights, and among those familiar with their use has created a desire for fuller technical information. In the past it has been an anomaly that while the regulating mechanism was studied very closely comparatively little information was available on the light yielded, and on such matters as the effect of different types of carbons. The important paper read before the Institution of Electrical Engineers on this subject by Messrs. Paterson, Walsh, Taylor and Barnett, on November 27th, which we summarise in the present number (see pp. 335–337) was therefore very timely. The authors present comparative data on a series of different types of carbons for searchlight work examined at the National Physical Laboratory during the war, and the photometric methods employed are fully described.

So far as the primary object of the investigations is concerned, it would appear that, generally speaking, there was not a great deal of difference in the performance of the different types of carbons tested in the ordinary standard form of searchlight, provided a good modern type of carbon is used; slight variations in manufacture do not very greatly affect the light. Possibly the choice of carbon would be determined rather by such factors as evenness in burning and constancy of operation. From the writer's experience he is fully aware of the earlier difficulties in producing carbons of uniform quality for such work, and the consistency of the results is a tribute both to the improvements that have been made in carbon manufacture during recent years, and to the skill and perseverance of the investigators carrying out these tests.

The discussion of the paper naturally turned largely on the methods of testing employed. The methods adopted show considerable ingenuity and present many features of interest. The authors originally attempted to test the carbons, as in actual operation, in searchlights in the open. According to this method conclusions would be based on the measurement of the beam-candlepower at a convenient distance. This method approaches closest to the actual conditions of use, but it is admittedly attended by great difficulties arising chiefly from variations caused by atmospheric conditions. On an appreciably misty night, as one would naturally expect, discordant results were recorded. But even on apparently clear nights similar great variations in apparent candlepower, which quite masked the differences from individual carbons, were met. The explanation of these irregularities, which have been experienced by others attempting to test searchlights in the open, seem somewhat obscure. Apparently even on a clear night there may be a considerable amount of varying absorption due to the scattering effect of particles suspended in the air, or the gradual formation of partially condensed water-vapour in the atmosphere. There is also the possible effect of air currents, or of damp air coming in contact with the carbons, affecting the operation of the arc and diminishing the brightness of the crater.

The authors accordingly abandoned the attempt to measure beam-candlepower in the open, and determined to test the carbons in a searchlight lamp, but without a mirror, placed in a large box with whitened interior. In these laboratory experiments very consistent results were obtained, and it is interesting to observe that the cubical box, in place of the globe-photometer, apparently gave satisfactory records of the mean spherical candlepower. It was, however, necessary to calibrate the box by means of a special lighting unit, consisting of an incandescent lamp with a conical reflector, giving a polar curve substantially similar to that of the arcs tested. Supplementary information was also gained by observations of the crater brightness, as determined from a projected image of the carbons.

The authors are to be congratulated on a useful and painstaking series of researches which afford a good groundwork for further experiment. We consider that data thus obtained are of considerable value in judging the effectiveness of carbons, affording a comparison of the total light emitted, and also, by means of the supplementary tests of crater-brightness, of the probable maximum candlepower of the searchlight beam. Another factor, less easy to determine, but of considerable importance in searchlight work, is the flux of light falling on the mirror which determines the average beam-candlepower.

We should very much like to see a fuller investigation of the conditions affecting tests of searchlights in the open, of which the authors' experiments afford some indication. Great as are the difficulties involved, it seems conceivable that in a more favourable situation, for example, at a fairly high altitude, well above low-lying mists and condensed water-vapour, more consistent results might be obtained. In view of the great future importance of searchlights in aerial navigation, we should like to see a determined attempt to devise a satisfactory testing station of this nature. Apart from this, the effect of atmospheric absorption is itself a subject which needs much more study than it has received in the past. The available information is extremely meagre, and we have still much to learn as to the exact nature of atmospheric absorption, the effect of varying densities of mist or fog, and the influence of the colour of the light. We put this forward as a subject well deserving further study.

The Lighting of Underground Passages.

In our last issue we referred to an interesting article on the lighting of the underground passages adjoining a new bridge at Cleveland, Ohio, recently contributed by Messrs. Ward Harrison and E. A. Anderson to the *Electrical World*. The most striking feature of this installation is the use of special diffusing glass panels, carrying gas-filled lamps immediately behind them, which are let in flush with the surfaces of walls and pillars. By this means a clear view down the passage is secured, and the lights are out of the line of vision. A further point is that in the various passages so lighted there have been no breakages of lamps due to mischievous action, *i.e.*, deliberate throwing of missiles by a section of the public ; whereas in sections which are lighted with similar appliances, but in the form of pendant lanterns, quite a number of breakages have been reported. It looks, therefore, as though, to some minds, the mere exhibition of a glaring lighting fitting is a temptation to throw things at it, whereas an inconspicuous lighting device escapes these attentions.

By the courtesy of the authors we are reproducing in this number (see pp. 338, 339) some photographs of the installation, since received.

The problem of lighting underground passages is of considerable interest to Londoners. On the tube systems there are perhaps greater lengths of passages of this description than in any other city of the world. London is also provided with subways crossing various busy thoroughfares and with tunnels crossing the Thames, and many of the chief railway stations have underground passages of some length.

Mr. Cunnington, in his paper before the Illuminating Engineering Society last February, described, as a good instance of underground passage lighting, a subway having girders across the ceiling between which lamps were effectively concealed. In cases in which the structure of a passage is completed before the lighting is installed, lamps in small diffusing glass globes, mounted direct on the ceiling, give fairly good results. But naturally the best solution is only reached when the design of the structure of the subway and the lighting arrangements are considered simultaneously. A good opportunity of demonstrating the advantages of such forethought was afforded to the tube railways. As is generally recognised, the lighting arrangements on the Underground Railways of London in this respect show considerable ingenuity, very happy results being obtained by the placing of lamps cut in slots in the ceiling, while on escalators new and somewhat difficult problems in lighting have been skilfully dealt with.

Many of the public subways crossing main thoroughfares, make use of white tiled surfaces which diffuse the light well. In some instances, however, the lamps are unshaded and the effect somewhat glaring to a person entering the subway from the relatively dark street. Conversely the contrast between a brightly lighted subway and a dark street is apt to be distracting to the eye of a person emerging from the subway, and might possibly prove a contributory cause to accidents. The possibility of grading the illumination in some way, so that the eye has time to become adapted to the altered conditions, should be borne in mind.

Natural and Artificial Lighting in Factories.

While the question of artificial lighting in factories is the subject of constant discussion, comparatively little is commonly said on the subject of natural lighting, which, nevertheless, is surely quite as important. One reason for this, doubtless, is the fact that it is always possible to remodel the artificial lighting, and at least to modify defects that may exist, whereas the conditions of natural lighting are practically determined by the window-space originally allotted in designing the building, and it is usually an expensive and difficult matter to make structural alterations at a later stage. To some extent access of daylight into a factory may be improved by the removal of neighbouring obstructions, or by the use of special devices, such as mirrors or prismatic glass, to redirect the light; substantial improvements may often be also effected by whitening interior surfaces which have become dusty and discoloured by age. But the two fundamental factors are the site of the building, and the nature of the structure.

It is therefore of great importance that this question of natural lighting should be kept well forward when new factories are built. The war has afforded quite exceptional opportunities in this direction. Many entirely new large factories have been built, and in many cases the choice of site was less subject to the controlling factors, such as expense, which apply in ordinary times. An instance is afforded by the extensive motor-repair works at Slough, which were recently inspected by a party of technical journalists. An account of this visit appears on p. 353, and we should like to add a few remarks on the nature of the lighting arrangements. Owing to the extensive site available the majority of the buildings are on the one-story plan, and there are no obstructions in their vicinity. So far as could be judged the facilities for access of daylight were exceptionally good, ample windows being provided at the side and general use made of overhead skylights—a combination which makes the fullest use of daylight. The artificial lighting, which is still in course of installation, also seems to be proceeding on satisfactory lines, provision being made for general overhead lighting with gas-filled lamps in suitable reflectors. Apart from special cases where the direction from which light comes is of vital consequence, and carefully placed local units are desirable, this general overhead system of lighting finds great favour. Its advantages have been often summarised, and it has the merit that the distribution of light resembles that from overhead skylights and side windows, thus affording a natural transition from daylight to artificial illumination.

Another favourable factor, we understand, is that the artificial lighting was settled at an early stage in the erection of the buildings. We lay stress on this because it is in the case of *new* factories that really adequate natural and artificial lighting may justly be expected. The difficulties imposed by alterations while work is in progress are often such that some managers are reluctant to re-design their lighting except when compelled to do so. But in the new factories being erected this does not apply, and there is no excuse for defective lighting. We trust, therefore, that in taking action on this matter the authorities will aim at laying down principles governing both natural and artificial lighting, to apply specially to new factories and to form part of the machinery of the amended Factory Acts.

LEON GASTER.

CARBON ARCS FOR SEARCHLIGHTS.

By C. C. Paterson, J. W. T. Walsh, A. K. Taylor and W. Barnett

(Abstract of a Paper read before the Institution of Electrical Engineers.)

A PAPER read by Mr. C. C. Paterson and his co-workers before the Institution of Electrical Engineers on November 27th, describing a series of tests undertaken for the Admiralty on searchlight carbons, contained much interesting information, both as regards the properties of carbons and the conditions under which their illuminating value could best be tested. The object of the paper were summarised as follows :—

(A) To develop the best method of testing carbons in order to prove their value for searchlights. (B) To compare the relative qualities of existing carbons, other than flame carbons, for producing high-intensity searchlight beams. (C) To determine what improvement can be made either in the carbons themselves or in the methods of burning them.

The first question that arose was naturally the conditions under which the tests should be made. The original idea was to measure the candlepower by actual tests on searchlights with an illumination photometer in the open-air. But it was found that variations in atmospheric conditions, the effect of wind, etc., imposed such difficulties as to make the results of tests very uncertain. Apart from the effect of draughts it was found that, even on apparently clear nights, inconsistent results were obtained, apparently owing to the scattering effect of fine particles in suspension in the air ; there were also uncertainties arising from small differences in the manipulation of carbons, *e.g.*, the position of the positive with respect to the mirror.

Accordingly the idea of making tests in actual projectors in the open was abandoned in favour of laboratory experiments.

The carbons were burned in an integrating photometer of cubical form, and simultaneous measurements were made of the average candlepower given by the arc and of the surface brightness of the positive crater. A comparison was thus made of 13 different types of carbons. The carbons were tested without any mirror. Two quantities have mainly to be considered : (i.) The total flux of light emitted by the carbons alone. (ii.) The intrinsic brilliancy of the positive crater. The latter is the more important, since it is a measure of the candlepower of the projector-beam. Crater brilliancy provides a direct criterion of the maximum intensity, provided the searchlight is adjusted to give a beam of minimum divergence. But, with a beam of given divergence it is also useful to know the total flux of light embraced by the mirror irrespective of size and brilliancy, as on this depends the average intensity of a beam of given dispersion. However, the difficulties of making measurements of the light emitted within a given solid angle led to the postponement of this form of test and the preliminary results given are based on measurements of total flux, which are easier to obtain.

The principle of the integrating globe photometer has been explained by Dr. W. E. Sumpner* and, for these experiments, a whitened cube would give as good results as a sphere. It is necessary to choose for the calibration of the cube a standard lamp which has approximately the same distribution of light as the lamp to be tested, and the authors illustrated a form of unit answering this requirement, namely, a 240 volt 1,000 watt vacuum lamp with a suitable opaque reflector above it. The calibration was carried out daily in view of gradual discolouration of the walls of the cube. The integrating cube used in the present investigation has 8 cubic metres' capacity (2 metres side). Two images of the arc, in directions at right angles to each other and to the axis of the carbons, were projected through the walls of the cube, thus permitting examination of the arc while burning. The electrical measuring instruments, feeding and locating arrangements, and electromagnetic control were controlled from outside, so that there was no necessity to open the cube except to change carbons. Ventilation was provided by means of adjustable shutters at the sides and top. Readings were taken simultaneously of crater brilliancy and candlepower. The intrinsic brilliancy was measured by projecting a magnified image of the front of the crater along a photometer bench. The normal brightness of the crater is obtainable by several methods, (1) from the formula :—

---

* ILLUMINATING ENGINEER (London), 1910 Vol. III., p. 323.

$$B = \frac{C''t'(x')^2 R}{r^2 nm} \cdot \frac{1}{(x')^2}$$

where C'' is the candlepower of the comparison lamp. t' the transmission coefficient of the colour filter, x', the distance of the comparison lamp from the photometer, r the radius of the positive lens, n the transmission coefficient of the positive lens, m the reflection coefficient of the mirror, and R is the illumination at the screen *plus* the illumination at the photometer determined by actual measurement, using a portable brightness photometer; (2) by measurement of magnification and allowance for the absorption of light in the lens system; (3) by substituting for the arc a 500-watt "Point-o-lite" lamp, the surface brightness of a part of the plate of this lamp having been previously determined in candles per square millimetre on a standard photometer bench.

The first seven carbons studied were supplied for a comparison of their light efficiencies with that of a special impregnated carbon developed by Messrs. W. Heape and H. B. Grylls. Subsequently a series of carbons was specially made up and supplied by the General Electric Company, with the object of obtaining the best type of carbon for an average burning current of 200 amperes. The lamp in which the carbons were burned was an old Crompton type for the 90 cm. searchlight with automatic and hand-feed gear. It was at first presumed that the candlepower would vary both with a potential across the arc and with the current, but investigation showed that while the P.D. and the arc length increased or diminished together, a large change in these quantities produced no sensible alteration in the average candlepower. The general position may be summarised as follows: A long arc, for any given carbon, whether from impregnated carbons or not, implies a high potential; and a short arc, a low potential. In order to obtain, under working conditions, a given amount of light from a given positive carbon, it is only necessary to pass through it a given current, the voltage across the arc and the arc length required to avoid hissing being immaterial. A positive carbon taking 200 amperes at 70 volts, *i.e.*, 14 kw., will emit the same light as one taking 200 amperes at 10 volts, *i.e.*, 20 kw. From the point of view of light emission from the positive crater, the extra 6 kw. are wasted. However, in order to ensure that all but a small proportion of the light directed towards the mirror from the positive carbon misses the negative, it is necessary for the arc length to exceed a certain minimum figure, and to obtain carbons which will take the maximum current through the positive crater at this minimum arc length, thus securing all the light possible with the minimum amount of dissipation of heat at the arc.

Consideration must also be given to specific differences in the light emission of different carbons. However, for the types of carbon considered, there seemed to be no sensible difference either in average candlepower or in crater brightness for carbons of the same diameter run at the same current. The efficiency in candles per ampere, increases somewhat for the same current density as the diameter of the positive carbon is increased, probably owing to the greater relative cooling surface of the smaller carbons. A number of curve sheets are given in the Paper to support these conclusions. Data were also presented giving the results of average candlepower tests on the seven types of uncoppered carbons tested. The average candlepower, for all these carbons, was found to depend only on the current and the area of the positives. The empirical expression deduced from these curves is of the form: Average candlepower $= Ai + Ba - C$, where i is the current and a the nominal cross sectional area of the positive carbon in square millimetres. For this set of carbons $A = 150$, $B = -5$ and $C = -2{,}000$. Hence, it is evident that the candlepower will increase with the area for a given current density. Apparently no increase in efficiency can be secured by increasing the diameter of the positive beyond 28 mm., the rate of increase in candles per amperes from this point onwards being very small. The maximum current which any uncoppered carbon could carry without overheating is given approximately by the formula : $i_{max} = 1{\cdot}8\, d^{1{\cdot}4}$ where d is the diameter of the positive in millimetres. By the aid of these formulæ it was deduced that the maximum candles per ampere should be obtained with a 34 mm. positive taking about 250 amperes ; this gives 124 candles per ampere, a result almost identical with that actually obtained with the 28 mm. positive at 154 amperes. Since the relation between candlepower and current density was invariably a straight line it is evident that none of the carbons tested showed any appreciable specific light emission. All positives were uncoppered. The maximum current density, beyond which carbons become unduly hot and begin to disintegrate, was about 0·3 amps. per sq. mm. If higher current densities are desired the positives should be coppered.

Some tests with one of the coppered positives were presented. This was run at currents from 150 to 220 amperes and a P.D. ranging from 58 to 86 volts with an arc length of 25 to 42 mm. The thickness of coppering was 0·06 mm. This apparently resulted in an increase in the slope of the (candlepower)/(current) curves, and in shifting the intercepts on the axis of the current. This last was equivalent to an increase in the size of the carbon. At 220 amperes the average candlepower of the six carbons did not differ by more than 13 per cent. from the mean. In all cases the negatives were of 16 mm. diameter and heavily coppered. If smaller ones were used the coppering volatilised and the carbon gradually disintegrated and diminished in diameter when the current exceeded 180 amperes.

At some of the shorter arc lengths employed the proportion of light obscured by the tip of the negative carbon cannot be neglected. The degree of obscuration can be calculated if it be assumed that (i.) the positive crater radiates as a circular disc emitting light according to the cosine law ; and (ii.) the negative may be regarded as a circular disc parallel with the positive and at a distance from it equal to the arc length. The first assumption is probably close to the truth for all ordinary carbons, but the second assumption is open to question because : (A) the diameter of the negative carbon becomes considerably reduced at the end, and (B) the effect of obscuration by the stem of the negative carbon with its holder is neglected. Another effect, which tends to offset the result of the reduction in diameter of the negative, is the reduction in the diameter of the positive carbon. These effects, partially counteract one another. Neglecting these corrections, the percentage of the light emitted from a positive crater of diameter D which is obscured by a negative of diameter d at an arc length a is given by the formula :

$$\frac{50}{D^2}\left\{(D^2+d^2+4a^2)-\sqrt{[(D^2+d^2+4a^2)^2-4d^2D^2]}\right\}$$

Finally, there is one other consideration to be borne in mind. For a 36 in. projector of about 16·5 in. focal length, only 70% of the total light from the crater falls on the mirror. All the obscured part of the light is within the angle embraced by the mirror, so that the effective obscuration of the useful light is 1·4 times that given by the formula, and the obscuration may amount to approximately 10%.

In the discussion following the paper attention was directed chiefly to the question whether the results of laboratory tests can be fully applied to determine the actual behaviour of carbons in practice. Practical trials out of doors are admittedly difficult but it was suggested that they might give useful results as a supplement to the more accurate laboratory experiments, and there are various factors, such as the flux of light actually embraced on the mirror which it would be desirable to ascertain.

A NOVEL SUBWAY LIGHTING INSTALLATION.

In a recent issue of this journal* we referred to the account given in the *Electrical World*† by Messrs. Ward Harrison and E. A. Anderson of the method of lighting employed in the subways attaching with a new bridge at Cleveland, Ohio. By the courtesy of the authors and the National Lamp Works of the General Electric Co. (U.S.A.) we have now received copies of the photographs some illustrating the original article, which we are reproducing herewith.

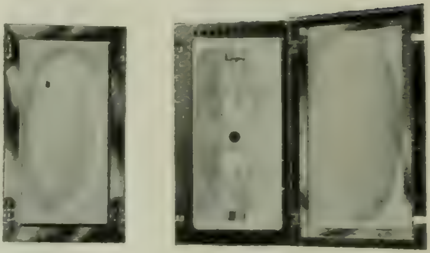


FIG. 1.—Panel Fittings carrying two gas-filled lamps screwed behind a hinged plate of diffusing glass.

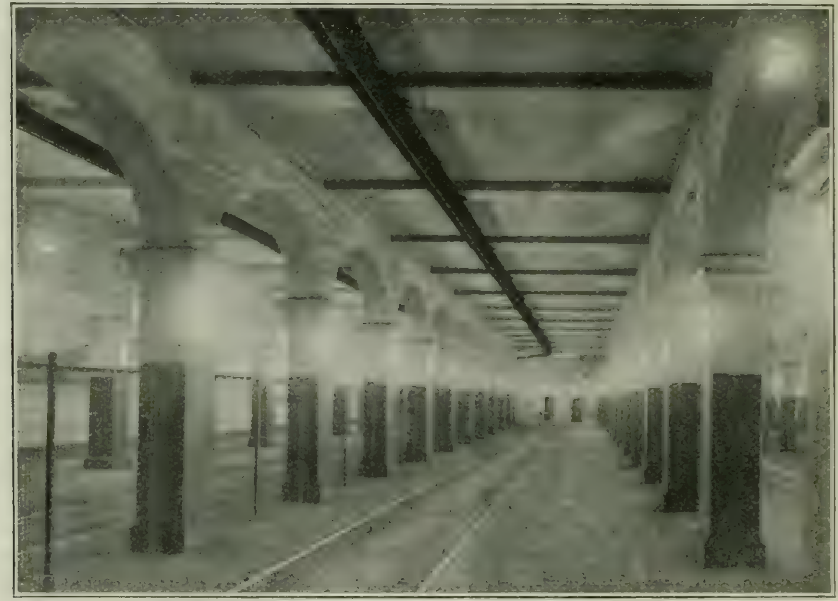


FIG. 2.—General view of Underground Passage showing panel fittings flush with pillars.

It will be recalled that the chief feature of the installation was the use of special forms of diffusing units, which, whereever possible, were set in flush with the walls of passages or pillars, so as to give a completely unobstructed view. Fig. 1 shows the details of these panel-fittings, which consist of a box containing two 75-watt gas-filled lamps, one or both of which can be switched on. The front of the box, set flush with the wall or pillars consists of a plate of diffusing glass, such that the filaments of the lamps are completely concealed. It will be recalled that one incidental advantage of this unit, apart from the good lighting conditions

---

* ILLUM. ENG., Oct. 1919, pp. 292. 293.

† *Elec. World*, Sept. 21, 1919.

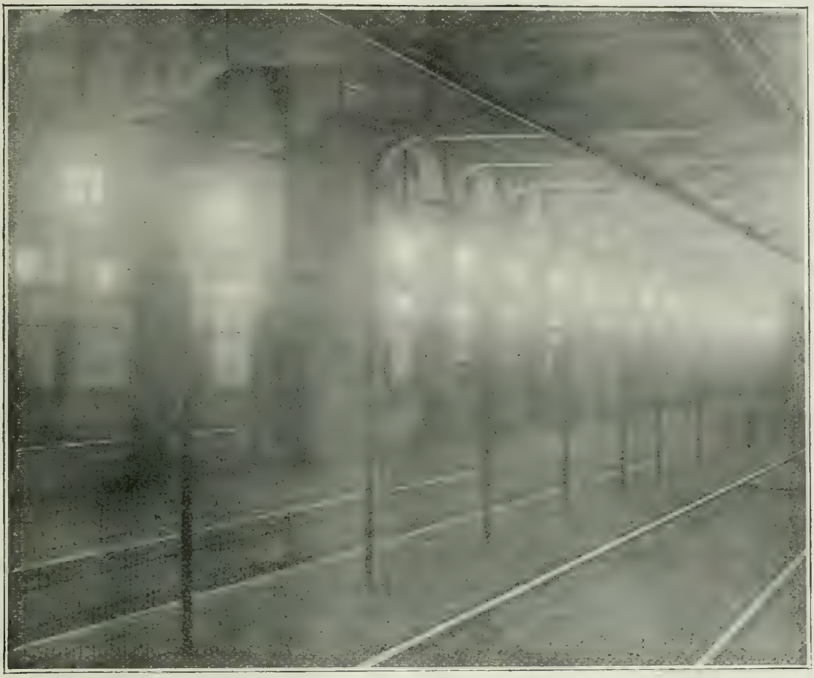


FIG. 4.—Showing pendant fittings in similar style to panel-type.

secured, is that the liability to breakages is diminished. Owing to the lamps being concealed and unobtrusively situated mischievous breakages by missiles, which are a common trouble with pendant fittings, do not seem to occur.

Fig. 3 shows a typical view of a passage with the fittings mounted in the walls, and Fig. 2 shows their installation flush with pillars. As the concrete work of the subway passenger station at the east end of the bridge was completed before the lighting was considered, it was not possible in this case to use the panel type of fitting. Instead pendant units were designed to give the same general effects, and these are seen in Fig. 4. This last style of fitting is also continued on the roadway and side walks of the upper level of the bridge.

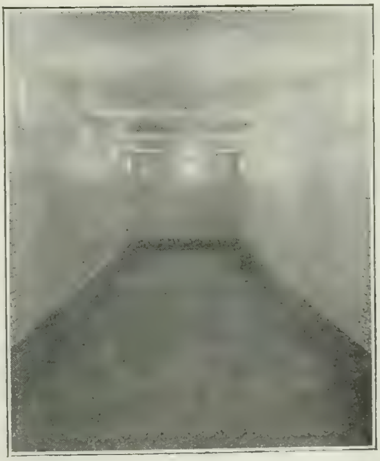


FIG. 3.—View of Underground Passage with panel fittings flush with walls.

Fuller particulars of this interesting installation were given in our issue for October, 1919.

STREET-SAFETY AND LIGHTING CONDITIONS.

AT the meeting of the London "Safety First" Council on December 15th an abstract of the article by Ward Harrison in the *Electrical World*, on "Street Lighting and Traffic Accidents,"* submitted by Mr. L. Gaster, was presented. It was resolved :—

(1) That the Commissioners of the Metropolitan and City Police be invited to co-operate with the Council in the issue of data similar to that given in the foregoing abstract, to include, if possible, time and number of accidents, lighting conditions, and districts in which they occurred.

(2) That such data, if and when received, be referred to Mr. Gaster for tabulation and report.

Attention was also drawn to the extract from THE ILLUMINATING ENGINEER entitled "Scientific War-Time Lighting in Paris,"† as confirming the views of the Council in regard to the lighting precautions suggested by it in connection with raids on the Metropolis by hostile aircraft.

FLOOD LIGHTING OF THE NIAGARA FALLS.

A RECENT issue of the *Electrical World* contains an account of the flood lighting installation, illuminating the Niagara Falls, which was put into operation by the Prince of Wales pushing a button on the evening of October 18th. The main battery of lighting units is divided into nine banks of nine units each : 1,000-watt lamps being used throughout. There are also some supplementary 500-watt units, placed on the Table Rock House, lighting a section of the falls more obliquely. The distances of projection are exceptionally great, varying from 800 to 1,300 feet, the total height of the falls is 158 feet and the illuminated area 316,000 sq. feet. Besides illuminating the vertical area of the falls themselves, light is also devoted to the horizontal region at their base.

A ROMANTIC BEACON.

ACCORDING to the *Daily Express* the village of Weldon, Northamptonshire, possesses an interesting and historic beacon, namely, a large tower carrying an immense octagonal lantern 15 feet high, and bearing on each side 12 panes of glass. The lantern accommodates 60 candles in oak candlesticks of strange design. For many years the lantern was lighted on dark nights in order to guide travellers through the once dense forest of Rocklingham. The practice has fallen into disuse, but during the past two and a half centuries a light has always been placed in the lantern on New Year's Eve.

MOBILE LIGHTING SETS.

IN the *General Electric Review*, Mr. S. Baldwin recently described three types of light-weight searchlight equipment mounted on motor vehicles for field service, and equipped respectively with 20, 50, and 60 k.w. generating sets. While primarily designed for war service these units should prove useful in other directions, *i.e.*, as fire brigade searchlights, in emergency work in the event of railway accidents, etc., and in enabling various kinds of work to take place at night at places where electric supply is not available.

LIGHTING IN THE CITY OF LONDON.

THE City of London, in common with other sections of the Metropolis, has now restored its street lighting to practically pre-war lighting conditions. Mr. W. J. Liberty, the Public Lighting Inspector, had recently an opportunity of explaining the various systems employed to Mr. M. Uchisaka, a representative of the Japanese Illuminating Engineering Society, who has recently been on a visit to London. Mr. Uchisaka has recently also visited the chief cities in Europe, with a view to studying lighting conditions and is making a similar tour of the chief cities in the United States.

---

* See ILLUM. ENG., October, 1919, p. 286.

† See ILLUM. ENG., October, 1919, p. 285.

ARTIFICIAL DAYLIGHT.*

THE PROBLEM OF MATCHING COLOURS.

By A. P. Trotter.

It is well-known that colours look different by daylight and by lamplight, and it is common to see a customer going to the door of a draper's shop to match a tint. To produce "artificial daylight" for the matching of silks and colours for artists' studios, picture galleries, etc., or for more delicate operations, such as the testing of dyes, or the grading of flour, we have to remove from artificial light the superfluous red orange and yellow rays.

In 1892, in a paper before the Institution of Electrical Engineers on the light of the electric arc, I suggested that "a glass or other medium might be tinted with stains or dyes which will absorb the proper amount of yellow and red light . . . or a reflecting screen may be painted with such a colour that this yellow light may be absorbed and the white light alone may be reflected." By aid of the luminosity curves determined by Sir W. Abney for the electric arc, for the flat flame gas burner and for the sun, it was shown how such curves may be treated to give the requisite luminosity curve for a daylight-correcting screen. A pale blue would suffice for the electric arc—the only illuminant then practicable for this purpose.

Twenty years later, when the tungsten lamp was introduced, further experiments were made. I first experimented with a spectro photometer made for me by Messrs. R. and J. Beck, Ltd., later with a box containing a disc on which were mounted a set of Winsor and Newton's specimen tints, illuminated by the light of a tungsten lamp, passing through coloured glass. Outside the box was a similar disc illuminated by daylight and the effect of artificial and natural light could thus be compared. A bluish glass gave a good match for some colours; yellows and reds were fair, but some blues became greenish, others violet. Spectroscopic examination showed that this was due to the fact that the blue glass was coloured with cobalt, having marked absorption bands; on the other hand, glass coloured with copper was too green.

In 1913 and 1914 several makers of electric lamps produced blue glass bulbs, and some tests of these were described before the Illuminating Engineering Society. The results were encouraging, but not entirely satisfactory. The late Professor Thompson also tested such lamps, and found them fairly satisfactory, although the delicate tones of his beautiful water colours were not rendered as by daylight. Moreover the method of employing a coloured glass bulb is subject to the drawback that the glass becomes unduly hot and the life of the lamps is shortened.

Colour-matching by artificial light has been discussed at several meetings of the

---

* Abstract of an article in *The Times* Engineering Supplement, December, 1919.

Illuminating Engineering Society, for example in a paper presented by Mr. T. E. Ritchie in 1912. Professor Gardner, of the Bradford Technical College, devised a filter of blue-green glass containing copper and cobalt which has been used in the factories of Bradford and Huddersfield for colour-matching work. Mr. T. Thorne Baker has made similar experiments with the incandescent gas light, and Dr. Kenneth Mees, in 1910, made a screen coloured with certain fast dyes, for use with tungsten lamps, and intended to produce a light both visually and photographically correct. Mr. Lionel Pearce showed a small lantern fitted with special daylight glass at the British Scientific Products Exhibition last year.

The latest attempt to imitate daylight is represented by the Sheringham Daylight device exhibited by Mr. L. C. Martin before the Illuminating Engineering Society in November last. In this case the transmission method is not utilised, but the light of the lamp is directed on to a reflector, covered with a mosaic of squares of green and blue paint, selected and proportioned to give the desired quality of reflected light. Paints are more easily procured and handled than coloured glass, and there is a wider choice of tints. But apparently pigments of the intensity required cannot reflect more than about 20 per cent. of light, whereas experiments made in America suggest that by transmission through suitable glasses it might be possible to use 60 per cent. of the light. The advent of the gas-filled lamp, giving a whiter light than the ordinary vacuum lamp, is favourable to improved efficiency. In 1911 Messrs. H. E. Ives and M. Luckiesh in America proposed the combination of light green glass with cobalt glass, and a gelatine screen dyed with rozaeine to neutralise the excess of green. Attempts have also been made to add the blue and green rays deficient in artificial illuminants, instead of subtracting the red orange and yellow, by the addition of supplementary lamps strong in green and blue: but the results have not been very successful.

More than one maker of coloured glass has supplied me with samples, but manufacturers were not sufficiently interested to experiment with special mixtures, because only the scientific side of the question was offered to them. If an order for £500 worth of glass had been promised then the result might have been different. In trying to place daylight glass on the market it is found that there is an impenetrable barrier of wholesale and retail dealers between the glass manufacturer and the ultimate consumer. The customer simply buys what is offered to him and the names of manufacturers are unknown. With lamp-makers it is different. If they make good colour-true bulbs, this will help them to sell their lamps. If a fairly long life can be secured this will be the most simple method; but it seems a pity to throw away the carefully made blue glass when the lamp has finished its life.

Returning to the scientific aspects of the matter, the question arises, " What is the colour of daylight? " Abney and Russell have found little difference between the hue of direct sunlight and that of light from an overcast sky, as far as their measurements went. Artists, however, recognise distinct variations in colour, according to the period of the day and time of the year. With a colour-matching apparatus it is easy to estimate these differences, and in an ordinary studio north light there is a wide difference between light received from a blue sky, a sun-lit cloud, and a winter sky. For most purposes a July afternoon light is good enough, and is cheaper to imitate than a cold north light or blue sky light, as less yellow and red light need to be absorbed.

In producing artificial daylight the object in view should be considered. For artists' studios and picture galleries there should be little difficulty: the main thing is to prevent the blues from darkening and the yellow from turning pale. For dye-works accurate matching should be possible, and in the grading of flour a very small deficiency of blue in the artificial light makes the hue appear slightly yellow. Drapers have rooms where their goods may be seen by ordinary artificial light, with a view to trying their appearance when worn by night, and a beginning might be made by having " daylight " rooms where their appearance by natural light could also be studied.

EARLY USES OF GAS-LIGHTING ON FESTIVE OCCASIONS.

A RECENT issue of the *Copartnership Journal* gives an interesting account of the first early records of the use of gas lighting on occasions of public rejoicing. Among celebrated occasions in pre-gas days interest attaches to the acquittal of the seven bishops, who were tried on June 29th, 1688, for protesting against the unconstitutional action of James II. Their release was celebrated by a general blaze of illumination, the favourite device being to place in each window seven candles, the centre one taller than the others to represent the Archbishop. On March, 1789, there was another great illumination to celebrate the recovery of George III. from his illness. London, it is said, " displayed a blaze of light, the illuminations extending from Hampstead and Highgate to Clapham, and even as far as Tooting ; while the vast distance between Greenwich and Kensington presented the same dazzling appearance. . . . There was not a house, large or small, not a cottage, nor the humblest dwelling of the poor, but what showed some sign of lighting up, even to a rush light. . . . The poorest mechanics contributed their proportion, and instances were exhibited of cobblers' stalls decorated with one or two farthing candles." At Hyde Park Gate was a grand triumphal arch on which were devices in coloured lamps of the crown, star and initials (a device which we seem to remember seeing reproduced in modern celebrations not infrequently, both with gas and electric lighting !).

The first record of the use of gas in connection with public rejoicings was apparently the illumination of Soho Works, the Factory of Matthew Boulton and James Watt, in Birmingham, on the occasion of the Peace of Amiens in 1802. Here, again, the devices seem to have been on familiar lines, such as the monogram "G. R." and the word "Peace," and "Montgolfier balloons at intervals" might be likened to the evolution of aircraft to-day.

The most interesting data given by the *Copartnership Journal*, however, relate to the suggestion of Winsor that gas should be used for beacons, which had long been regarded as an essential part of mobilisation arrangements in times of national peril. While the shadow of Bonaparte still lay across Europe many beacons were kept in readiness, but in 1803, after the Peace of Amiens had failed, some objection was taken to the cost of the beacons and some were discontinued. Mr. Winsor, with characteristic enterprise, approached Mr. Walter Spencer-Stanhope, a Member of Parliament interested in the question, in the following letter :—

Sir,—By a conversation in the House of Commons on Friday, the 9th of March, between Messrs. Cook, Addington, Pitt, C. Wynne, Spencer-Stanhope, Lord Temple, etc., it was stated—

That in the West Riding of Yorkshire one of the five beacons after having cost £10,000, had been abandoned on account of the enormous expences. Judging from this that the whole expenditure for the numerous Beacons and Lighthouses all over the Empire must be very considerable, I beg leave to request your acceptance and perusal of the annexed publication respecting a new discovery of making a most powerful, brilliant flame *from common smoke* of all kinds of fuel by which a very great saving may be obtained. Page 23 I have only touched on the subject of Lighthouses, to which I add that far superior lights might be established all over the Empire at less than a quarter of the present expence.

As soon as my Patent has obtained his Majesty's signature, I shall publish my book, and set up some Publick Place to show all the wonderful effects and great savings to be derived from common smoke, which hitherto evaporates from millions of chimneys of the world. My apparatus is only temporarily fixed up in a private house, and I shall be happy to convince you and your friends of the truth of my assertion any day and hour that you may please to appoint.

I am very respectfully, Sir,
Your most obedient servant,
F. WINSOR.

City Coffee House, March 12, 1804.

P.S.—Having had the honour of knowing Arthur Stanhope Esqre, your relation, for some years, he advised me yesterday to forward my publication to you without loss of time, in giving me your address; perhaps, Sir, you may appoint a time together to come and see a private experiment, as Mr. A. Stanhope seemed to be a great amateur of similar trials.

To Walter Spencer-Stanhope, M.P.,
Grosvenor Square.

The "annexed publication," it is remarked, was probably Winsor's "Account of the Most Ingenious and Important National Discovery for Some Ages—British Imperial Patent Light Ovens and Stoves." As Winsor was born in Moravia and had derived his idea of gas-lighting from a Frenchman (Phillipe Lebon), the notion of labelling the project "British Imperial" was distinctly good. In the pamphlet there is a statement that :—

The lighthouses on our coast may be rendered like blazing stars, to guide our seamen over the watery deep; nay, the very signals of vessels and fleets by night, may be materially improved, and rendered more distinct than in the brightest days.

In conclusion it is of interest to give one other quotation from Winsor's pamphlet, which, as our contemporary suggests, shows that the advertising art was fully appreciated a hundred and fifteen years ago :—

"As to illuminations, they may be carried on to the utmost extent of beauty and variegated fancy, by this docile flame, which will ply in all forms, submit to instant changes, ascend in columns to the clouds, descend in showers from trees, walls, &c., arise from the water, and even in the same pipe with a playing fountain.

"The constant varying of the flames in rooms and gardens, between pyramids, festoons, garlands, roses, flambeaus, &c., &c., afford to the spectator an extraordinary and most delightful sight; cherish the soul, and create good humour, by uniting conveniency, utility and pleasure."

THE MEASUREMENT OF SHADOW.

IN a recent communication to the German Illuminating Engineering Society, Dr. K. Norden described a simple device for judging the density of shadows prevailing in a lighting installation. Assuming that the actual horizontal illumination, E, is due to the combined effects of a number of sources, each yielding respectively a, b, c, .. foot-candles, then the shadow cast by any one light is due to the withdrawal of these respective component illuminations. The illumination in the shadow cast by one of these lamps would thus be $E-a$, and the factor a/E is termed the "shadow-quotient." One can obtain this factor by measuring E and $E-a$ with a photometer, but more readily by a special device which the author described. This device consists of a series of 15 tinted sectors, ranging from white to dead black through grey, the coefficient of reflection of each sector, in relation to white, being indicated by a number. The sectors are arranged in the form of a circle, white spaces being left between each two adjacent tinted ones. A rod at the centre of the disc throws a shadow of the light examined, and by rotating the disc this shadow is caused to fall on the white portion intermediate between two tinted areas such that there is approximate balance of brightness. In this way the ratio $E-a/E$, and hence also a/E, is quickly determined.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(Abstract of the Report of the Committee on Progress of the Illuminating Engineering Society, U.S.A., presented at the Thirteenth Annual Convention in Chicago, October 20th to 23rd, 1918.)

DURING the war-period energy has been concentrated mainly on the production and supply of necessary material, with the result that there are few striking advances in the manufacture of lamps and lighting appliances to report. At the same time public appreciation of the importance of illumination has probably never been exceeded.

During the past 100 years the average American family has not departed widely from an expenditure of 24 dollars (present value about £6) per annum for light, and is thus spending about the same amount as a century ago. But for this sum about twenty times as much light is received.

In England the effects of diminished street-lighting have served to confirm the importance of good lighting in thoroughfares, enforced economy has promoted a closer study of illumination; the war has also driven home the need for closer co-operation. In the United States a greater recognition of the need for educational measures in connection with illumination is evident, and was illustrated by the exhibit, demonstrating the best methods of lighting for various kinds of interiors, shown at the annual convention of the National Electric Light Association. The interest taken in improved school lighting is shown in an investigation carried out at the request of the Trustees of the Board of Education in Chicago by an illuminating engineer to the Federal Government. Much attention is also being paid to industrial lighting. The Inspector of Factories in British Columbia mentions cases of saw-mills where the lighting was so inadequate that the inspector had to be furnished with a lantern in order to perform his duties!

Gas Lighting.

Reference is made to the work of the National Gas Council in England, and to various expedients for the distillation of gas from lignite, etc., from abroad. Some new sources of natural gas have been developed near Pisa, in Italy.

Progress in burners has been mainly in the direction of low candlepower units, new types having been introduced to supersede flat flame burners. One type designed abroad consumes only $\frac{1}{2}$ cub. ft. per hour, the flame impinging on a flat fabric. The need for economy in the use of coal has led to energetic efforts to replace flat flame burners in the United States, but such burners are still used occasionally where strong draughts or exceptional vibration are considered prejudicial to mantles.

The Report of the Research Committee of the British Institution of Gas Engineers on the effect of quality of gas on burners is referred to, and the new basis of recoking based on British Thermal Units per candlepower is discussed. A change in calorific value will in some cases require a modification of nipple orifices.

The Report of the Fuel Research Board in this country suggesting standardisation of burners and appliances for calorific values of 400, 433, 466 and 500 is also mentioned. The Bureau of Standards (U.S.A.) has also been occupied with this matter, and discusses a basis on which B.Th.U.'s might be applied. The Indiana State Commission has authorised a survey of all gas plants in the State with a view to the possible adoption of a calorific standard, either of 528 B.Th.U. or some standard other than the 600 in use. This is said to be the first survey of the kind in the U.S.A. The United States Fuel Administration has decided to leave the matter for the decision of the Public Service Commission in each State.

Some elaborate studies of the radiation of the mantle have been made, and it is pointed out that a rise in temperature from 1900° K. to 2100° K. would increase the efficiency of radiation about three times.

Electric Incandescent Lamps.

Advances have been confined mainly to special lamps used for cinematograph work and in situations requiring very rugged construction. A new material for filaments, namely, an alloy containing zirconium and iron has been patented, a favourable feature claimed being the slight tendency to oxidise and the high selective emission. Miniature lamps have been used in increasing quantities. Of ordinary lamps the 40-watt type is most popular, with the 25-watt next. The average lumens per watt of lamps sold (including gas-filled lamps) is now about three times that available in 1907, when tungsten lamps were first introduced. Two forms of gas-filled lamps have been standardised for cinema work, one operating at 600-watt, the other at 900-watt, both 30 volt.

On September 15th, 1918, it was agreed that, with a view to making a saving in fuel, the manufacture of carbon filament lamps should cease, except in a few isolated cases. During October, however, 100,000 carbon filament lamps were imported from Japan. The restriction has since been repealed, but the displacement of carbon lamps by tungsten lamps continues.

Prior to the war the output of lamps in France was about 15 to 20 million, but it is hoped that this figure will be doubled in the near future. The manufacture of lamps has been started successfully at Santiago, Chile. In Norway the manufacture of lamps has also increased during the war.

A recent development is the 50-watt gas-filled type of lamp having a bulb of white glass, diffusing the light so that the filament is invisible. A "Mill-type" form of vacuum lamp, specially adapted to withstanding shock and vibration, has been developed. 25 and 50-watt types are made. The filament mounting is flexibly attached to the base by a piece of steel wire in order to absorb vibrations, and each alternate filament is attached to an additional anchor in order to prevent overlapping. The efficiency is intermediate between the ordinary tungsten lamp and the carbon filament lamp, and the lamp is still in the experimental stage. Small lamps are now made in the form of an annulus for microscopic work. This is a 9 volt 0·7 amp. type with blue glass bulb to imitate daylight.

Tests of lamps installed in parks have shown that the life depends more on the number of times the lamp is switched on and off than the actual total burning hours. Recent experiments on gas-filled lamps show that the ratio of hot to cold resistance is roughly 15, and that the change in candlepower for 1 per cent. change in voltage varies from 2·4 to 3·4 according to type on d.c. and somewhat less on a.c. Candlepower first increases and then decreases during life, a corresponding change taking place in the resistance. In England the proposal has been made to standardise voltages, namely 100, 110 and 115 for low voltages, and 200, 220 and 230 for high voltages. In the United States an increase of 12 per cent. in the number of companies operating at the standard voltages of 110, 115 and 120 is noted.

Arc Lamps.

A new form of lamp utilises an envelope of low-expansion material such as sodium-magnesium or boro-silicate glass, with a cathode of tungsten, tantalum or carbon. The anode is of metallic calcium, magnesium or other metal highly reactive to gases other than the inert rare gases. The voltage required to start the lamp is low and the drop across the arc may be as low as 4 to 5 volts. A 15 amp. arc may be formed on 14 volts, if the cathode temperature is 2500° C. A new quartz tube mercury lamp with an annular bulb has also been described. Water cooling is used and it is stated that the current may be varied from 2 to 10 amps. and the pressure from 25 to 150 volts. The candlepower is reported to reach 5000 with a specific consumption of 0·2-watt per candle. Tests have been made in Germany on a U-shaped CO_2 Moore Tube, 3 m. long and 40 mm. in diameter. A minimum specific consumption of 4·9 watts per candle (Hefner) was attained; with nitrogen the figure was 1 to 2 watts per candle (Hefner). With a tube containing neon and a little helium 0·26 watts per Hefner, and with a similar tube containing argon 0·45 watts per Hefner were recorded. The use of such lamps for signalling is suggested, in view of the penetrating nature of the light. In a new form of neon lamp described in Germany no high tension discharge is necessary, the lamp glowing at once on a 220 volt circuit. A 210 volt lamp was found to give 0·44 Hefner, consuming only 4·0 watts.

Searchlights and Lamps for Projection Purposes.

A new form of searchlight, a modification of the Beck and Sperry types, is recorded. The arc pressure is reduced from 70 to 50 volts, 120 amps. being consumed. Searchlights for coast defence and anti-aircraft work have been standardised in four types with 60, 90, 120 and 180 cm. diam. mirrors. Distant control has been largely adopted in preference to hand control. The Army Engineer Corps in the United States developed a type of searchlight weighing only one-eighth as much as those formerly in use, of only one-fourth the bulk and one-third the price, with a 10 per cent. increase in intensity as compared with other portable projectors. Many railway companies have equipped locomotives with high candlepower headlights, 6 volt. 108-watt lamps of a rugged type being recommended. New forms of motor-car headlights involve optical devices to subdivide the beam of the main part of the light illuminating the road at a distance, but a subsidiary portion used in the form of a dispersed beam to light the road immediately in front of the car. Another method utilises only one high candlepower electric lamp, which apparently supplies the conventional number of headlights, side, dash and tail lights. The light is distributed to the various needed positions by a system of lenses and mirrors.

Small portable flashlights for signalling, operated from batteries strapped on the back of the observer are mentioned. Experiments have shown that signals can be transmitted as fast by making and breaking the lamp-circuit as by the use of shutters; fluctuations in the light of lamps switched off and on occur at least as fast as the eye can observe ordinary Morse signals.

Various small forms of arc lamps for cinema work have been described, one of these having a water-cooled copper ring for the negative pole, placed concentrically round the end of the positive carbon. The arc travels round the space between ring and central electrode and the lights from the latter is not obstructed. For taking cinema pictures outside the studio a special twin carbon lamp cored with a magnesium compound, and stated to give from 8,000 to 15,000 candlepower has been described. To avoid hard shadows the light is filtered through a spun glass screen. Another self-contained twin arc lamp is fitted with a triangular shadow-breaking device, softening the double shadows apt to be produced by lamps of this type.

Miners' Lamps.

The Home Secretary in Great Britain appointed in 1918 a Commission to inquire into and report upon possible improvements in miners' lamps. A form of approved lamp, utilising a battery in a steel case with magnetic lock, weighing 6 lbs., and giving not less than 1 candlepower for 9 hours has been described. A miner's acetylene lamp, described before the Institute of Mining Engineers, may be used to detect the presence of fire-damp and lack of oxygen. A double glass serves as a protection against contact of flame with adjacent gas and an automatic burner is included to maintain a sufficient temperature to reignite the gas should the lamp be extinguished by shock. The Bureau of Standards has issued a circular on dry cells.

Luminous Devices used in War.

Various special devices of this type are described. "Trench truncheon torches" could be used either as a lamp, or in emergency as a weapon, and were said to give 30 hours continuous burning, or three months flashlight use. Areoplane flares developed in France were stated to give 150–175 times the light of an average street arc lamp. "Invisible" signalling was carried out by a special 6 volt electric lamp, equipped with a lens and giving a very narrow beam. Filters were used by night to cut out all but the ultraviolet, and red screens in daylight. The range was about six miles and such devices were used to communicate with observation posts. For naval convoy work mercury vapour lamps with chimneys of glass transmitting only ultraviolet were used, the receiver condensing the image on to a barium platinocyanide screen. A range of four miles was found possible. As an aid to traffic by night large discs 25 in diam. coated with luminous paint were used, being visible at a distance of 30–60 feet but not conspicuous to the enemy. They were also used for short distance signalling. Luminous ribbons were attached to the backs of stretcher bearers.

Lighting Restrictions.

A summary is given of lighting restrictions and diminutions in private and public lighting in the interests of fuel economy, which, in the main, are familiar to readers of this journal.

Street Lighting.

The extensive development of motor-traffic in the States has had a marked effect on street-lighting. A new development announced by the Bureau of Mines is the illuminated "safety island" to mark intersections of streets for the convenience and safety of traffic. Improvements have been made enabling series of street lighting circuits to be controlled from the power house. A summary is given of street-lighting developments in various American cities, and some account of the use of illumination to mark the signing of the Armistice. Instances of the use of flood-lighting for various special purposes are also mentioned.

Interior Lighting.

Great attention is being paid to industrial lighting, two features of importance being its influence on possible 24-hour schedules, and in enabling work to proceed during periods of fogs and inconvenient climatic conditions. Instances of the use of indirect and semi-indirect lighting in churches are mentioned. In theatres indirect units using different combinations of coloured lights have been introduced. In a recently completed cinema artificial light is provided from windows in the ceiling. As an example of specialised lighting the new City Hall in San Francisco is interesting. At the entrance are ornamental standards with the upper part shaped like a bishop's crook bearing an ornate lantern with crystal panels and a frosted 1,000-watt lamp inside. Similar lanterns are used in the rotunda, and special cove-lighting is used to illuminate the interior of the dome.

In Wisconsin State Capital the illumination on desks has been increased from a minimum of 1·1 to a minimum of 6 ft.-candle. Merely painting the centre panels of the ceiling white enabled the energy consumption to be reduced from 2,240 to 1,500 watts with but little diminution in illumination. In factories the tendency has been towards standardisation, illumination values ranging from 2 to 8 ft.-candle being recognised. The United States Railroad Administration has issued specifications relating to electric lighting of railway equipment. Attention has been given to the need for good lighting in central stations round circuit breakers and switches. The use of ceiling-lights for such work often gives rise to inconvenient shadows, best avoided by lamps at a lower level.

Fixtures and Reflectors.

Attention is drawn to metal reflectors having an upper portion cut out and replaced by a cone of diffusing glass, thus preventing undue obscurity of the ceiling and upper part of room. Composite forms of units have been devised which, by arrangement of parts, can be made to serve either for direct, indirect or semi-indirect lighting. Forms of totally enclosed indirect lighting units, claimed to be dust-proof are mentioned. A new development is a form of reflector capable of adjustment so as to suit different types and sizes of gas-filled lamps.

A new flood-lighting unit makes possible a distribution of light covering 24°, with an effective efficiency claimed to be 75 per cent. New street-lighting units utilise an inverted pyramid type of reflector with a view to diverting rays in directions slightly inclined to the horizontal and thus improving distribution of illumination. Generally speaking fixture-dealers are beginning to realise the advantages of standardisation.

Photometry.

Cubical boxes with whitened interiors have been successfully used instead of globes for determining m. sph. candle-power, notably at the National Physical Laboratory. A new form of integrating photometer has been devised in Germany, using diffusing white surfaces in place of mirrors. Reference is made to the special photometers devised by the British Illuminating Engineering Society for tests of flares for the Ministry of Munitions. Photo-electric cells, used on the "null method" have been applied to spectrophotometry. The colour-sensibility of photo-electric cells has been further discussed, and advances are reported in overcoming inertia, fatigue and other disturbing factors in selenium cells. The possibility of devising a standard of light based on the maintenance of a black body at a known temperature has been discussed.

Physiological Experiments.

The fact that, a bright haze in the atmosphere will shut out from view objects behind it was made the basis of an instrument, termed a "visibility meter," used to study the effect of camouflage on the appearance of ships during the war. Radio-active self-luminous preparations have proved useful in testing minimum light sense and retinal adaptation.

It has been shown that the sensation of luminosity created when light gradually increases to a maximum, is much less than when the light starts at maximum intensity. Much work has been done on persistence of vision. The latter has been shown to be a maximum at the centre of the retina and to diminish towards the periphery. Tests have shown that the use of gas masks influenced visual acuity, which was diminished 20 per cent.

Legislation.

Interest in legislation requiring good illumination in factories is growing. It has been pointed out as a drawback in America that each State tends to form a code of its own; common procedure may be adopted in the future. The general tenor of existing codes is similar, but the prescriptions relating to glare are the subject of discussion. Detailed schedules of the illumination necessary for various processes have been issued, *e.g.*, by the New York Industrial Commission, 25 per cent. of the initial illumination being allowed as a factor of safety for deterioration of lamps and fittings.

ILLUMINATING ENGINEERING SOCIETY, U.S.A.

PROGRAMME OF PAPERS FOR SESSION 1919-1920.

We have received from the Illuminating Engineering Society in the United States a programme of meeting for the present session, which is as follows:—

Oct. 17*th*, 1919.—"The Scope of the Society, and its place in the Engineering Field," by G. A. Hoadley (President) and S. E. Doane (Past-President).

Nov. 21*st*, 1919.—"Industrial Lighting," by G. H. Stickney.

"Lighting and the Householder," by M. Luckiesh.

Dec. 8*th*, 1919.—"The Regulation of Automobile Headlighting," by C. H. Sharp and W. F. Little.

Jan. 16*th*, 1920.—"School Lighting," by M. Luckiesh.

Feb. 20*th*, 1920.—"Artificial Daylight Equipment," by N. MacBeth.

March 19*th*, 1920.—"Development of the R.L.M. Standards for Industrial Lighting," by Ward Harrison.

"Residence Lighting," by M. Luckiesh.

April 16*th*, 1920.—"Daylight Saving," by P. S Millar.

May 21*st*, 1920.—"Colour Photography," by H. Hess

TRAINING EX-SOLDIERS IN ENGINEERING.

Our attention has been drawn to the scheme for training ex-soldiers in engineering, administered by the Appointments Department of the Ministry of Labour. The Training Grant Scheme covers practically all professional, commercial and business occupations, and it is considered that there is no adequate reason why it should not apply to the engineering trades. While, generally speaking, every industry and calling has shown its willingness to take its share of ex-Service men for training, objections have been raised by the Engineering Trade Unions on various grounds. It has been suggested, for example, that the trainees would fill the better positions to which ordinary industrial apprentices aspire, and that many industrial apprentices are still with the Colours, and many trade unionists out of work. It is pointed out, however, that the number of trainees should not exceed 1,750, less than one-third per cent. of the total membership of the engineering trade unions, and that the number of trainees in any factory would not exceed one per cent.; further, that most of the engineering trade apprentices are now demobilised. The grants are intended to assist men whose parents are in needy circumstances, and in view of the above facts it is hoped the scheme will receive general support by the engineering industry.

THE PATENT OFFICE LIBRARY.

Readers will be glad to hear that a movement is on foot to secure the restoration of the hours during which the Patent Office Library was available to the public before the war, namely, until 10 p.m. It has been urged, with some justice, that the curtailment of hours during the war was a short-sighted economy. Whatever reasons might have been urged on this point during the war, however, there is surely no reason now why pre-war privileges should not be restored. The evening hours afford the only opportunity for using this library to many students and busy professional men. We are glad to observe that a petition is to be addressed to the Board of Trade on the subject, with the support of leading scientific and technical bodies. The matter is of interest to the technical press and was brought forward at a recent meeting of the Institute of Journalists. Those interested can obtain particulars of the petition from Mr. Chas. Salter, 33, Park Hall Road, Finchley, N. 2.

ROYAL INSTITUTE OF PUBLIC HEALTH CONGRESS IN BRUSSELS.

The next Annual Congress of the Royal Institute of Public Health is to be held in Brussels during May 20th—24th, 1920, on the invitation of Burgomaster M. Adolphe Max. In the Section of Industrial Hygiene, of which Sir Thomas Oliver is the British President, special attention will be devoted to the subject of Lighting in Factories.

ANNUAL EXHIBITION OF THE PHYSICAL AND OPTICAL SOCIETIES.

The annual exhibition of the above two societies is to be held at the Imperial College of Science, South Kensington, on January 7th and 8th, 1920, and will be open from 3 to 6 p.m. and from 7 to 10 p.m. on both days. Several interesting lectures have been arranged, including that by Professor F. J. Cheshire on "Some Polarisation Experiments," at 8 p.m. on January 7th, and that by Professor A. O. Rankine on "The Use of Light in the Transmission of Speech," at 4 p.m. on January 7th. Those interested should apply to the Secretary of the Physical Society, National Physical Laboratory, Teddington, S.W.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.

We have received a short history of research undertaken by the above Institution, and observe that it is proposed to call a conference early in the new year with a view to arranging for the continuation and extension of this work. The conference will be held at University College and the co-operation of other bodies interested in heating and ventilation is invited.

THE SOCIETY OF GLASS TECHNOLOGY.

At a meeting of the Society of Glass Technology held at Sheffield University on December 17th, Dr. W. E. S. Turner, the Secretary of the Society and lecturer in charge of the department of glass technology at this University, was presented with a cheque and silver tea and coffee service. Mr. Frank Wood, the first President, was presented with a silver rose bowl, and it was stated that the Society intends to form a Wood Prize in the glass technology department at Sheffield University.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments. and we welcome the receipt of all *bona-fide* information relating thereto.]

A NEW INDUSTRIAL LIGHTING UNIT.

THE Dispersive Mazdalux Reflector, recently developed by the British Thomson-Houston Co., Ltd., has several interesting features. It is made in four sizes from 13¼ ins. to 22 ins. diameter for half-watt lamps of from 60 to 1500 watts. The light distribution is midway between that yielded respectively by the extensive and intensive forms and the units being spaced a distance apart equal to 1¾ times their height above the working plane. The angle of "cut-off" is 85 degrees, and the reflector is therefore considered particularly suited to conditions requiring the illumination of vertical surfaces.

The reflector forms a complete unit, being provided with a top housing and suspension hook. A bayonet, Edison screw, or Goliath screw lampholder, is also included, according to the size of lamp. The reflector is made of sheet steel, stiffened with a beaded lower edge. The interior is finished with white vitreous enamel, which, besides providing a satisfactory reflecting surface, does not readily collect dust, and is easily cleaned. French grey enamel is employed to protect the exterior of the reflector.

One distinguishing feature of the reflector is the deep skirt, which increases the dispersion of the light rays. The concentrated form of the half-watt lamp filament is an obstacle to wide distribution, but this difficulty has here been surmounted by the addition of the skirt to the parabolic upper portion of the reflector. Dispersive Mazdalux reflectors are supplied in a modified form (known as the "Dispersa" Lantern) with weatherproof housing made of cast iron, for outdoor use.

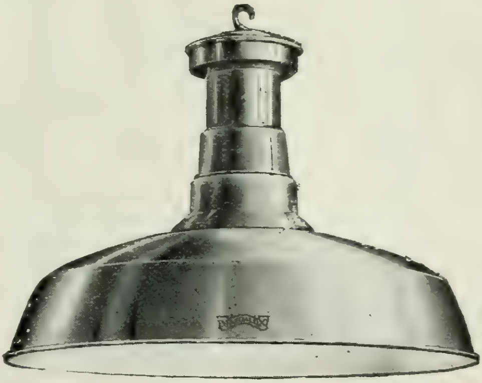


FIG. 1.—Dispersive Type Mazdalux Metal Reflector for Industrial Lighting.

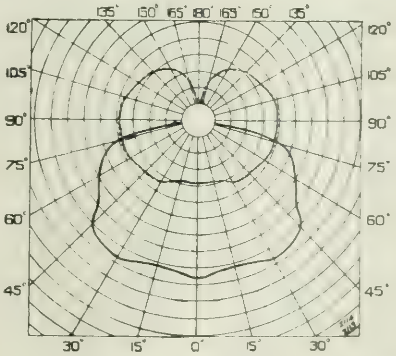


FIG. 2.—Polar Curve showing characteristic light distribution of Dispersive Mazdalux Reflector and Mazda half-watt type lamp.

VISIT TO THE WORKS OF MESSRS. WM. SUGG AND CO.

On Friday, December 5th, a party of members of the London and Southern District Junior Gas Association visited the works of Messrs. W. Sugg and Co., Ltd., in Regency Street, Westminster. During the war the firm, in common with others, has been largely engaged on special war work, but the regular manufacture of gas lamps has now been fully resumed.

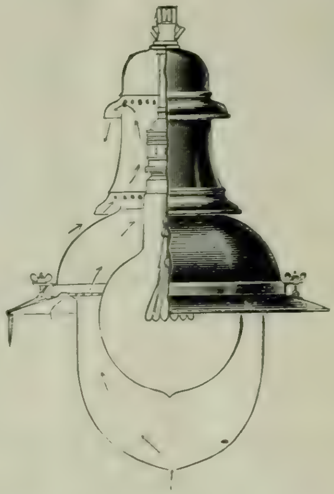
The visitors were welcomed by Mr. Mattock, the General Manager, who recalled the early pioneering work of the late Mr. William Sugg, the founder of the present company. Mr. Lofts, the Sales Manager, also explained the nature of the work on which the firm is occupied, the special feature being the low pressure inverted lighting. At present, owing to the different qualities of gas prevailing in various districts, it was impracticable to send out lamps with fixed nipples and gas-ways. An air-regulator was necessary under present conditions.

A feature of the visit was the exhibit of the testing rooms where lamps are being examined prior to their dispatch. At present attention is being concentrated largely on two forms of lamps, the "Littleton" and the "No. 7176" and experience shows the desirability of providing lamps with several small mantles, so as to distribute the light, rather than one big one. A fuller account of the visit has appeared in the *Gas Journal*.

GLASS TOP METAL REFLECTORS.

An interesting novelty has recently been developed in the United States, namely, a type of metal reflector which is not "all-metal" but consists of a lower metal hood attached to a conical neck-piece of diffusing glass. The advantage claimed for such "glass top" reflectors is that a certain amount of light is allowed to escape upwards, illuminating the ceiling and preventing the somewhat dark effect in the upper part of the room that is apt to be noticeable when ordinary opaque reflectors are used. We have thus a lighting unit that is a compromise between the conditions characteristic of diffusing or prismatic glass units and the metal type commonly used for industrial lighting. The development is interesting and deserves attention in this country.

THE "MELTON" LANTERN.



A recently issued catalogue from Messrs. Falk, Stadelmann and Co., Ltd., contains data on a series of useful lanterns for use with gas-filled ("half watt") lamps.

Special interest attaches to the Melton Lantern, illustrated herewith, which we recently had an opportunity of inspecting at the company's showrooms. The lantern has a bold and pleasing outline. The filament is situated level with the rim of the reflector. Lanterns can be fitted with a cast brass adjustable lamp-carrier, enabling the filament to be focussed to the correct position, ensuing suitable distribution of light. When desired a globe having all but a small upper annulus obscured, may be used—a form which seems to have advantages when wide spacing is necessary. The lantern is stated to be thoroughly weatherproof and, as the illustration shows, special attention has been paid to ventilation—a very vital matter with gas-filled lamps. The contour of the enamelled reflector, besides being designed with a view to efficient light distribution, gives ample space for a cooling chamber so as to avoid overheating. No screws are used in mounting the casing, which is readily detached.

The lantern is made in two sizes, suitable for 500 watt and up to 1500 watt size; the latter, however, is regarded as equally suitable for smaller lamps, in cases where only a small candlepower is necessary, but an imposing lantern is wanted.

INDEX, December, 1919.

PAGE
Artificial Daylight. By A. P. Trotter 341
Carbon Arcs for Searchlights. By C. C. Paterson, J. W. T. Walsh, A. K. Taylor, and W. Barnett 335
Circle of Scientific, Technical, and Trade Journalists :—
  Visit to the Motor-repairing Works at Slough 353
Editorial. By L. Gaster 331
Floodlighting of the Niagara Falls 350
Gas, Early Use of, for Lighting on Festive Occasions 343
Illuminating Engineering, A Year's Progress in 345
Illuminating Engineering Society (U.S.A.), Programme for 1919–1920 349
Patent Office Library, The 350
Publications Received 354
Physical and Optical Society, Annual Exhibition of 350
Street Safety and Lighting Conditions 340
Subways, Lighting of 338
Topical and Industrial Section :—
  A New Industrial Lighting Unit—Visit to the Works of Messrs. Wm. Sugg and Co., Ltd.—Glass Top Metal Reflectors—The "Melton" Lantern .. 352
Training Ex-Soldiers in Engineering 350

SCIENTIFIC AND TECHNICAL CIRCLE OF THE INSTITUTE OF JOURNALISTS.

Visit to the Motor Repair Works at Slough.

By the permission of Lord Inverforth, the Minister of Munitions, arrangements were made by the Scientific and Technical Circle of the Institute of Journalists for a party of technical journalists to visit the extensive motor repair works at Slough on Monday, December 8th.

The works occupy a very considerable area, exceeding 600 acres, and operations are already being conducted on an extensive scale, although the equipment of some of the factories is not yet quite complete. The object of the works is the systematic repair of the very large number of cars and lorries in the Government service, surplus vehicles, however, being disposed of from time to time as circumstances admit. Visitors were shown various stages in the repair of motor cars, motor-lorries and motor-cycles. The general planning of the factories and the method of construction appeared to be quite up-to-date, good features being the general use of one-story buildings with abundant access of daylight. It is stated that the works are to be entirely lighted and driven by electricity, generated at a special power station where three 1,000 kw. generators are to be installed, one set being already in operation. The artificial lighting is also being installed on modern lines. In general this follows the approved plan of overhead lighting with gas-filled lamps in suitable reflectors. The installation, when complete, should be an interesting one. The party were conducted over the works by Mr. E. C. Given, of the Factory Department of the Ministry of Munitions, and everything possible was done to render the visit instructive and agreeable. The visitors much appreciated this opportunity of seeing for themselves the nature of the work carried on at this important depot.

PUBLICATIONS RECEIVED.

Eyesight in Connection with Education, By Dr. James Kerr. (Introductory paper at a discussion at the Ophthalmological Congress in London in May, 1919.)

THE above paper, which has been reprinted in pamphlet form, contains some interesting data on defective vision in school children, and suggestions for its treatment and the method of testing. The fundamental fact to be noted is that whereas almost all children start with good vision (in many cases better than "normal"), there is a progressive deterioration during school life. Thus Dr. Inglis Pollack, in his investigation in the Govan schools, found that up to 12, 13 and 14 years of age myopia ran to about 7–8 per cent., but above this age increased rapidly up to 19 per cent. Similarly Priestly Smith has found 5–6 per cent. of myopia in elementary schools and 20 per cent. in teachers' training colleges. Dr. Pollack's diagram showing the steady increase from five years upwards (where myopia was only about 2 per cent.) is very striking. Equally remarkable are the great differences in percentages for different districts, recorded by Dr. Kerr in diagram form, which suggest that variations in methods of testing may be one influential factor. Besides visual defects Dr. Kerr mentions unfavourable muscular developments, contortions, etc., due to undue concentration of effort, which may be accentuated by poor light or glare. The paper is concluded by a series of suggestions for further inquiry, stress being laid on the need for definite research under Education authorities in regard to ocular hygiene, in addition to routine vision-testing.

The Technical Inspection Association Gazette.

CONCERTED action by those who have taken part in the great war is now usual. The latest example is afforded by the association named above, which aims at gathering together the widely scattered experts engaged in inspection work. We notice that in addition to promoting the welfare of its members the Association includes in its objects the advancement of science and industry by promoting the efficiency of inspection and the conservation of experience gained in this branch of work during the war. For such an association an official publication is naturally of great value. The first copy of the *Gazette* contains accounts of recent meetings and technical matter of considerable interest.

Journal of the Franklin Institute, December, 1919.

THE *Journal of the Franklin Institute* for December contains several notes dealing with the glass industry. A paper recently read before the American Cermic Society by W. Washburn emphasises the importance of scientific research. In glass making it is remarked we at present know *how* rather than *why*. A distinction is drawn between (1) routine testing, (2) works problems, and (3) fundamental researches. In the glass industry almost all the fundamental research remains to be done; little is known of the relations between viscosity and temperature and composition, of the effects of surface tension and vapour pressure, and of the nature of gases remaining in solution, and their effect on the properties of glasses.

Another contribution, from the *U.S. Tariff Commission Information Bulletin*, surveys the optical glass industry in the United States. Results are promising, and in many cases the American articles are stated to be better than those formerly imported from the Continent. A third article by R. J. Montgomery attempts a classification of optical glasses which are divided into 23 groups.

Science and Industry (Official Journal of the Commonwealth Institute of Science and Industry, Melbourne, Australia).

THIS monthly bulletin, issued by the Commonwealth Institute of Science and Industry, deserves notice at the hands of British readers. The Institute is evidently doing a great deal towards fostering the application of science to industry in Australia. The copy of the bulletin before us, for October, 1919, contains articles emphasising the value of irrigation, and dealing with the flax and cotton industries, and shows how the various scientific problems occurring in connection with the special trades and industries of the Commonwealth are being dealt with.

TP
700
L54
v.12

Light and lighting

~~Physical &~~
~~Applied Sci.~~
~~Serials~~

Engineering

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE